University of Alberta

A Comparison Study of Cognitive Differences of Attention Deficit/Hyperactivity Disorder subtypes to a Clinic Control on the Stanford-Binet-Fifth Edition

©

By

Theodore Arthur Burrows

A thesis submitted to the Faculty of Graduate Studies and Research in partial
fulfillment of the requirements for the degree of Doctor of Philosophy
In
School Psychology

Department of Educational Psychology

Edmonton, Alberta
Fall 2008

Library and
Archives Canada

Published Heritage
Branch

395 Wellington Street
Ottawa ON K1A 0N4
Canada

Bibliothèque et
Archives Canada

Direction du
Patrimoine de l'édition

395, rue Wellington
Ottawa ON K1A 0N4
Canada

Your file Votre référence
ISBN: 978-0-494-46287-4
Our file Notre référence
ISBN: 978-0-494-46287-4

NOTICE:
The author has granted a non-exclusive license allowing Library and Archives Canada to reproduce, publish, archive, preserve, conserve, communicate to the public by telecommunication or on the Internet, loan, distribute and sell theses worldwide, for commercial or non-commercial purposes, in microform, paper, electronic and/or any other formats.

The author retains copyright ownership and moral rights in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author's permission.

AVIS:
L'auteur a accordé une licence non exclusive permettant à la Bibliothèque et Archives Canada de reproduire, publier, archiver, sauvegarder, conserver, transmettre au public par télécommunication ou par l'Internet, prêter, distribuer et vendre des thèses partout dans le monde, à des fins commerciales ou autres, sur support microforme, papier, électronique et/ou autres formats.

L'auteur conserve la propriété du droit d'auteur et des droits moraux qui protège cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

In compliance with the Canadian Privacy Act some supporting forms may have been removed from this thesis.

While these forms may be included in the document page count, their removal does not represent any loss of content from the thesis.

Conformément à la loi canadienne sur la protection de la vie privée, quelques formulaires secondaires ont été enlevés de cette thèse.

Bien que ces formulaires aient inclus dans la pagination, il n'y aura aucun contenu manquant.

Canada

Abstract

The cognitive profile of a sample of 118 children (ages 7-17) with Attention Deficit/Hyperactivity Disorders (ADHD) was compared to a sample of 62 non-ADHD clinically referred children using the Stanford-Binet Fifth Edition. This was an archival study utilizing a sample of children referred to the Education Clinic at the University of Alberta between the years 2003 and 2007. Classification of ADHD subjects and control was based upon multiple sources of evidence, including the scores from the Behavior Assessment System for Children (first or second editions) or the Conners' Rating Scales-Revised, as well as other clinically relevant information. The ADHD sample was broken into four groups, all ADHD individuals together (ADHD-collapsed; n=118) and the three subtypes; ADHD-combined (n=46), ADHD-inattentive (n=61), and ADHD-hyperactive (n=11). Analysis was completed for between-group and intra-individual difference levels. This included MANOVA of the five factor scores, as well as verbal and non-verbal Working Memory (WM) and Quantitative Reasoning subtests. Intra-individual difference analysis used ANOVA and chi-square of factors and subtests of interest. Intra-individual difference analysis examined the relative weakness of a particular score within an individual's overall profile. Of all five factors, WM was the only factor that showed significant differences across all the analysis. Significant findings for Verbal Quantitative Reasoning (VQR) occurred in the ADHD-inattentive group, differentiating it from the other subtypes in all analysis. Correcting for the number of comorbid conditions resulted in more significant findings at the subtest level. Results from the study also suggest the utility of differentiating subjects based upon severity of ADHD symptoms. Future

research comparing the subtypes to each other directly, based upon symptom severity, would be of interest.

Dedication

This work is dedicated to children with ADHD, to their parents/caregivers, and to the professionals who provide support. It is with hope that this work will add to the knowledge necessary to identify effective supports and interventions. It is with hope that this work will add to the understanding necessary for parents to advocate for their child and help overcome their own, as well as their child's, daily frustrations. Finally, but most importantly, it is with hope that this work will add to changes necessary so that children with ADHD may more easily overcome their challenges and enjoy their personal gifts. I offer this work as only partial repayment for the gifts provided by the above to me. These gifts include the lessons they have taught me about myself as a professional, as well as a person with ADHD.

Acknowledgement

I wish to acknowledge that this work would not have been possible without the support of many others. I would like to thank my supervisor Dr. Henry Janzen for his insight and guidance, as well as my committee members; Dr. Robert Short, Dr. Robert Klassen, Dr. George Buck, Dr. Carol Leroy and Dr. Fred French, for the supportive criticism and challenging questions that drove me deeper into the subject.

I wish to thank Dr. Hau Chow, who spent untold hours, usually on weekend, going through files with me, entering pages and pages of data, proof reading and providing honest and constructive feedback. But most of all, thank you for providing encouragement to me to persevere.

I wish to acknowledge Dianna King, as well as the staff of the Kildonan School, NY. Thank you for teaching me, and opening up a world of learning which I had never had access to before. Dr. Phil Katz, thank you for instilling in me a love for human behaviour and thought, as well as for being there.

To my large extended family, my grand parents, aunts, uncles, and cousins, you are the base of my strength. To my mother and my father, who shared in my frustrations yet continued to believe in me, and my brother and sister, for being there. To my aunt, Gail Cipryk, for your support and faith in this endeavor.

Finally, to my wife Barbara, and my daughters Sarah and Ashleigh, who lived with me, shared the sacrifice of grad school, and reminded me that one must also live in the moment. You kept me grounded and I could not have done this without your love and support.

TABLE OF CONTENTS

TOPIC Page

CHAPTER ONE: SCOPE OF THE STUDY

- Attention-Deficit/Hyperactivity Disorder (ADHD) 1
  - History of labelling ADHD 2
  - Controversy surrounding ADHD 3
  - Impact of ADHD on Children 3
  - Working Memory and ADHD 4
- Research Problem 6
  - Group Difference Approach 6
  - Intra-individual Difference Approach 6
  - Number Counts 7
- Definition of Terms 7
  - Executive Function 7
  - Working Memory 8
  - ADHD Cases 8
  - Clinical Control Cases 9
  - Learning/Cognitive Disorders 9
  - Psychiatric Disorders 9

CHAPTER TWO: SURVEY OF THE LITERATURE

- Theories of Underlying Causes of ADHD 10
  - ADHD as a Frontal-Subcortical Disorder 11
    - Pharmacological Findings 12
    - Neuroimaging Findings 12
    - Genetic Findings 13
  - Theories of the Executive Dysfunction Theories and ADHD 14
    - Baddeley 15
      - Phonological Loop 16
      - Visuospatial Sketchpad 17
      - Central Executive 17
      - Episodic Buffer 19
    - ADHD and Working Memory 20
    - Rapport 21
    - Barkley 23
    - General Research 25
- Comorbidity and ADHD 25
- Cattell-Horn-Carroll (CHC) Theory of Cognitive Abilities 27
- Cognitive Measures of Working Memory 29
  - Stanford-Binet Intelligence Scales-Fifth Edition (SB-5) 30
    - SB-5 Factors 31
    - SB-5 Subtests 32
      - Nonverbal Working Memory 32
      - Verbal Working Memory 33
      - Nonverbal Quantitative Reasoning 33

TOPIC Page

Verbal Quantitative Reasoning 33
SB-5 and ADHD 34
Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV) 37
Working Memory Index 38
Digit Span 38
Letter-Number Sequencing 39
Arithmetic 39
Reliability 39
Validity 40
ADHD and WISC-IV 40
Behavioural Measures 40
Behavior Assessment System for Children (BASC) 40
BASC-2 44
Hypothesis 45
Group Difference-Factor Scores 47
ADHD-collapsed 47
ADHD-combined 47
ADHD-inattentive 48
ADHD-hyperactive 49
Group Difference-Subtest Scores 49
ADHD-collapsed 49
ADHD-combined 50
ADHD-inattentive 50
ADHD-hyperactive 51
Intra-individual Differences-Factor Score Level 52
ADHD-collapsed 52
ADHD-combined 52
ADHD-inattentive 52
ADHD-hyperactive 52
Intra-individual Differences-Subtest Score Level 53
ADHD-collapsed 53
ADHD-combined 53
ADHD-inattentive 54
ADHD-hyperactive 54
Chi-square Analysis-Factor Score Level 55
ADHD-collapsed 55
ADHD-combined 55
ADHD-inattentive 56
ADHD-hyperactive 56
Chi-square Analysis-Subtest Score Level 57
ADHD-collapsed 57
ADHD-combined 57
ADHD-inattentive 58
ADHD-hyperactive 59

TOPIC Page

Hypotheses Statement Summaries 59
Rational 61
Limitations and Delimitations of the Study 61
Limitations 61
Delimitations 62

CHAPTER THREE: METHODOLOGY

Measures 63
SB-5 63
BASC/BASC-2 64
Reliability 65
Validity 66
SIDAC-R 66
Conners' Rating Scales-Revised 67
Design 67
Population 68
Sample Size and Case Selection 68
Study Group Selection Procedure 69
Stage One-Initial Criterion Review 70
Stage Two-Placement into Study Groups 73
Exclusion of FASD cases 74
Stage Three-Case Reviewed for Comorbidity 74
Stage Four-ADHD Subtype Identification 78
Statistical Analysis 79
Group Difference Analysis 79
Intra-individual Approach 80
ANOVA analysis of difference scores 80
Chi-square analysis 81
Power Analysis 83

CHAPTER FOUR: RESULTS

Study Group Characteristics 84
Comorbidity 91
Overall Cognitive Ability 95
BASC/BASC-2 Characteristics 95
BASC/BASC-2 PRS Results 97
BASC/BASC-2 TRS Results 99
SB-5 Results 100
Group Mean Differences on SB-5 Factor Scores 100
ADHD-collapsed 101
ADHD-combined 102
ADHD-inattentive 102
ADHD-hyperactive 103
Group Mean Differences on Subtest scores 104
ADHD-collapsed 104

TOPIC Page

ADHD-combined 105
ADHD-inattentive 106
ADHD-hyperactive 107
Intra-individual Analysis of Factor and Subtest scores 107
Factor Score Analysis 108
ADHD-collapsed 109
ADHD-subtypes analysis 109
Subtest Score Analysis 110
ADHD-collapsed 110
ADHD-subtypes analysis 110
Chi-square Analysis 111
Chi-square Analysis for Factor Scores 111
ADHD-collapsed 112
ADHD-combined 112
ADHD-inattentive 113
ADHD-hyperactive 113
Chi-square Analysis for Subtest Scores 113
ADHD-collapsed 114
ADHD-combined 115
ADHD-inattentive 116
ADHD-hyperactive 116
Summary of Results 117
Group Mean Differences 117
Intra-individual Analysis 123
Chi-square Analysis 127

CHAPTER FIVE: DISCUSSION

Summary of ADHD-collapsed Group Results 133
Delineation of ADHD Group Results 135
Group Difference Approach 136
Group Difference-Factor Scores 136
Group Difference-Subtest Scores 137
Intra-individual Differences Approach 139
Chi-square Analysis-Factor Score Level 140
Chi-square Analysis-Subtest Score Level 141
Impact of Controlling for Number of Comorbid Conditions 142
MANOVA 142
Mean Factor Scores 142
Mean Subtest Scores 142
ANOVA 143
Factor Difference Score 143
Subtest Difference Score 143
Methodological Considerations 144
Intra-individual Difference Approach 144
Subtype Comparisons 145

TOPIC	Page
Discussion of the Clinic Control Group	146
Severity of ADHD Symptoms	146
Effect of Correcting for Number of Comorbid Conditions	147
Discussion Related to Questions Raised by this Study	148
Group Difference-Factor Scores	148
Group Difference-Subtest Scores	148
Difference Score Analysis-Factor Score Level	149
Difference Score Analysis-Subtest Score Level	149
Chi-square Analysis	150
Implications of Findings	151
WM Deficits	151
Implications Regarding VQR Deficits	154
Implications Regarding Severe/moderate Differentiation	155
Implications for Subtype Differentiations	157
Implications for Cognitive Assessment of ADHD Subjects	159
Implications for Research	161
Limitations	161
Delimitations	162
Future Studies	163
REFERENCES	165
APPENDIX	186

LIST OF TABLES

Table	Topic	Page
2.1	SB-5 factors and subtests	32
2.2.	BASC-Teacher Rating Scale components	42
2.3.	BASC-Parent Rating Scale components	43
2.4	Summary of Hypothesis Statement of group mean differences, by study groups and SB-5 measures	60
2.5	Summary of Hypothesis Statement related to intra-individual differences, by study groups and SB-5 measures	60
3.1	Distribution of excluded cases by academic year and criteria.	63
3.2	Classification Criterions utilized in Stage I Grouping	70
3.3	Percentage of files missing specific information used for initial group selection	71
3.4	Stage I Evidence Criteria and Initial Grouping Categories with numbers of subjects	72
3.5	Study Groups and number of subjects	74
3.6	Evidence Sources for Determining Comorbid Disorders	75
3.7	Critical Values for the five factor scores and four subtest scores of interest	82
4.1	Percentages of final sample with various psychiatric diagnoses	85
4.2	Distribution of number of cases for each family history area	87
4.3	Subject Medical History	88
4.4	Educational History	90
4.5	Social and Legal Issues	91
4.6	Number of Comorbid conditions by type, ADHD-collapsed and clinic control	92
4.7	Number of Comorbid conditions by type, ADHD-combined	92
4.8	Number of Comorbid conditions by type, ADHD-inattentive	93
4.9	Number of Comorbid conditions by type, ADHD-hyperactive	93
4.10	Number of comorbidity by study group	94
4.11	ANOVA and Post hoc (Scheffe) analysis summary of BASC/BASC-2 Parent Rating Scale scores for each ADHD subtypes	96
4.12	ANOVA and Post hoc (Scheffe) analysis summary of BASC/BASC-2 Teacher Rating Scale scores for each ADHD subtypes	98
4.13	Number of subjects within each ADHD subtype group	100
4.14	MANOVA and Post hoc (Scheffe) analysis summary of factor scores for each ADHD subtypes	101
4.15	MANOVA and Post hoc (Scheffe) analysis summary of subtest scores for each ADHD subtypes	104
4.16	Summary of ANOVA results for the difference scores of ADHD-severe, ADHD-moderate, and Clinic Control group, uncorrected for number of comorbid conditions	108

Table	Topic	Page
4.17	Significance Values for Chi Square Analysis of Factor Scores for ADHD subtypes based on MSD critical values	112
4.18	Significance Values for Chi Square Analysis of factor Scores for ADHD subtypes based on RMSD - 10% critical values	112
4.19	Significance Values for Chi Square Analysis of Subtest Scores for ADHD subtypes based on MSD critical values	114
4.20	Significance Values for Chi Square Analysis of Subtest Score for ADHD subtypes based on RMSD - 10% critical values	114
4.21	Summary Table of Hypothesis Statements for Group Difference Analysis	117
4.22	Summary of Hypothesis Statements for intra-individual analysis	123
4.23	Summary of Chi-square analysis of significant difference counts	128
5.1	Significant findings for ADHD groups	135

APPENDIX TABLES

Table	Topic	Page
Table 1a	MANOVA table for factor scores ADHD-collapsed vs. clinic control	186
Table 1b	MANOVA table for factor scores ADHD-combined vs. clinic control	187
Table 1c	MANOVA table for factor scores ADHD-inattentive vs. clinic control	189
Table 1d	MANOVA table for factor scores ADHD-hyperactive vs. clinic control	190
Table 1e	Means and SD for factor scores	192
Table 2a	MANOVA table for subtest scores - ADHD-Collapsed	193
Table 2b	MANOVA table for subtest scores - ADHD-Combined	194
Table 2c	MANOVA table for subtest scores - ADHD-Inattentive	195
Table 2d	MANOVA table for subtest scores - ADHD-Hyperactive	196
Table 2e	MANOVA table for subtest scores	198
Table 3a	ANOVA table for QR Difference Scores: ADHD-collapsed	199
Table 3b	ANOVA table for WM Difference Scores: ADHD-collapsed	199
Table 3c	ANOVA table for QR Difference Scores: ADHD-combined	199
Table 3d	ANOVA table for WM Difference Scores: ADHD-combined	200
Table 3e	ANOVA table for QR Difference Scores: ADHD-inattentive	200
Table 3f	ANOVA table for WM Difference Scores: ADHD-inattentive	200
Table 3g	ANOVA table for QR Difference Scores: ADHD-hyperactive	201
Table 3h	ANOVA table for WM Difference Scores: ADHD-hyperactive	201
Table 3i	Difference score means and SD for factors	202
Table 4a	ANOVA table for NVQR Difference Scores: ADHD-collapsed	202
Table 4b	ANOVA table for NVWM Difference Scores: ADHD-collapsed	202
Table 4c	ANOVA table for VQR Difference Scores: ADHD-collapsed	203
Table 4d	ANOVA table for VWM Difference Scores: ADHD-collapsed	203
Table 4e	ANOVA table for NVQR Difference Scores: ADHD-combined	203
Table 4f	ANOVA table for NVWM Difference Scores: ADHD- combined	204
Table 4g	ANOVA table for VQR Difference Scores: ADHD- combined	204
Table 4h	ANOVA table for VWM Difference Scores: ADHD- combined	204
Table 4i	ANOVA table for NVQR Difference Scores: ADHD-inattentive	205
Table 4j	ANOVA table for NVWM Difference Scores: ADHD- inattentive	205
Table 4k	ANOVA table for VQR Difference Scores: ADHD- inattentive	205
Table 4l	ANOVA table for VWM Difference Scores: ADHD- inattentive	206
Table 4m	ANOVA table for NVQR Difference Scores: ADHD-hyperactive	206
Table 4n	ANOVA table for NVWM Difference Scores: ADHD-hyperactive	206
Table 4o	ANOVA table for VQR Difference Scores: ADHD-hyperactive	207
Table 4p	ANOVA table for VWM Difference Scores: ADHD-hyperactive	207
Table 4q	Difference Score Means and SD for subtests	208

Table	Topic	Page
Table 5a	MANOVA power tables, uncorrected	209
Table 5b	MANOVA power tables corrected for number of comorbid conditions	210
Table 6a	Intra individual analysis ANOVA power tables, uncorrected	211
Table 6b	ANOVA power tables corrected for number of comorbid conditions	212
Table 7	DATA SHEET	213

LIST OF FIGURES

Table	Topic	Page
Figure 4.1	Graph of WM difference score, study group and ADHD subtypes, including collapsed	219
Figure 4.2	Graph of QR difference score, study group and ADHD subtypes, including collapsed	220
Figure 4.3	Graph of VWM difference score, study group and ADHD subtypes, including collapsed	221
Figure 4.4	Graph of VQR difference score, study group and ADHD subtypes, including collapsed	222
Figure 4.5	Graph of NVWM difference score, study group and ADHD subtypes, including collapsed	223
Figure 4.6	Graph of NVQR difference score, study group and ADHD subtypes, including collapsed	224

CHAPTER 1: SCOPE OF THE STUDY

Attention-Deficit/Hyperactivity Disorder

Attention-Deficit/Hyperactivity Disorder (ADHD) is believed to impact the lives of 3% to 10% of children (American Psychiatric Association (APA), 2000; Faraone, Sergeant, Gillberg, & Biederman, 2003). The disorder is implicated in close to one half of all referrals to child psychiatric clinics (Anderson, Williams, McGee, & Silva, 1987; Cantwell, 1996). Controversy around diagnosis remains, with some studies suggesting that it remains under diagnosed overall, and over diagnosed in some populations (Cuff, Moore & McKeown, 2005). Currently ADHD is diagnosed through assessment of behaviour patterns that meet a specific criterion. According to the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR) (APA, 2000), the criterion for ADHD includes the existence of six or more symptoms of at least one of two clusters: inattention and/or hyperactivity-impulsivity. These symptoms must have existed for over six months, be maladaptive, and be inconsistent with the person's developmental age. At least some of these symptoms must have been present prior to the age of seven years and caused notable impairment of functioning in two or more settings. Clinically significant impairment in the areas of social, academic, or occupational functioning must also be present. An exclusionary criterion is also specified whereas the symptoms cannot be better explained by the presence of other mental disorders or conditions.

The DSM-IV TR (APA, 2000) provides nine examples of inattention including failure to attend to the details of activities such as schoolwork, difficulties sustaining attention on tasks or when being spoken to, avoidance of tasks requiring sustained "mental effort," problems with organization, and being easily distracted. In the second set of symptoms, hyperactivity-impulsiveness is described separately and also totals nine symptoms. Examples of hyperactivity include fidgeting, difficultly remaining seated in classroom settings, excessive talking, and general hyper-kineticism. Notably, the DSM-IV TR indicates that symptoms of hyperactivity may change to general feelings of restlessness in adolescence and adults. Symptoms of impulsivity include frequently interrupting others, blurting out answers, and difficulty waiting turn.

Depending upon the cluster of behavioural symptoms identified, ADHD can be coded into one of three subtypes. Attention-Deficit/Hyperactivity Disorder, Predominately Inattentive Type (ADHD-I) requires at least six symptoms of inattention, but less than six symptoms of hyperactivity/impulsivity. Attention-Deficit/Hyperactivity Disorder, Predominately Hyperactive/Impulsive Type (ADHD-H) requires six or more symptoms of hyperactivity and/or impulsivity, but less than six of inattention. Attention-Deficit/Hyperactivity Disorder, Combined Type (ADHD-C) is coded when an individual exhibits six or more of both symptom sets.

History of Labelling ADHD

The name, diagnostic features, and suspected underlying cause of ADHD have undergone considerable revisions over its' rather extensive history. Indeed, between 1902 and the early 1960's approximately 10 different terms were used to identify what is now termed ADHD (Anastopoulos & Shelton, 2001). In 1968 the term Hyperkinetic Reaction of Childhood was used in the DSM-II, becoming the first uniform diagnostic guidelines (APA, 1968). Although vague, it identified hyperactivity and inattention as the chief diagnostic criteria. The DSM-III (APA, 1980) changed the term to Attention Deficit Disorder with Hyperactivity, reflecting a growing realization of the importance of deficits of attention (Douglas, 1972). Attention Deficit Disorder with Hyperactivity included a subtype, ADD without Hyperactivity. In 1987 the DSM-III-R listed both ADHD and Undifferentiated Attention Deficit Disorder (UADD), where the symptoms of inattention, hyperactivity, and impulsivity were undifferentiated in a list of 14 symptoms (APA, 1987).

Controversy Surrounding ADHD

The debate into the nature and diagnostic features of ADHD continues. A number of studies have questioned the validity of the three subtypes listed in the DSM-IV-TR. Faraone, Biederman, Weber, and Russell (1998) found few differences between them in terms of academic and social functioning, gender ratios, or cognitive functioning. Others have questioned whether ADHD-I is indeed a distinct and separate disorder (Lockwood, Marcotte, & Stern, 2001). Other studies have found these divisions valid. Barkley (1997b) and others have criticized the current diagnostic criteria as being dependent upon externalized behaviours and without an underlying theory to explain these. Barkley and Biederman (1997) have argued that the requirement of symptom age of onset is also unreasonable, especially in the case of ADHD-I type.

Impact of ADHD on Children

ADHD has been associated with a vast range of social, behavioural, and academic/occupational difficulties in both children and adults. Usually first diagnosed in school, the disorder can have a detrimental impact upon a wide range of abilities, such as attending to class discussions or lectures, organizing school material, and sustaining attention to written material. In addition to these academic related tasks, ADHD has been seen as being responsible for various behaviours that can result in problems with peers and school staff. This can include such things as difficulty staying seated in class, blurting out answers, making inappropriate comments, general fidgetiness, and poor social interactions with peers.

Poor decision-making compared to peers has been noted by various studies. Children diagnosed with ADHD tend to take greater risks (Barkley, 1998), and they have difficulty with delayed reward (Barkley, Edwards, Laneri, Fletcher & Metevia, 2001; Sonuga-Barke, Williams, Hall, & Saxton, 1992).

Along with problems related to the primary behavioural features of ADHD, children with ADHD frequently suffer from various comorbid learning and other behavioural disabilities. These include developmental disorders such as various learning disorders (Semrud-Clikeman, et al., 1992), Tourette's syndrome, and behavioural disorders such as oppositional defiance disorder and conduct disorders, depression and anxiety disorders.

Working Memory and ADHD

Convergent research from studies of the biological substrates of ADHD have found deficits in the prefrontal cortex area (Castellanos, et al., 2002; Seidman, Valera, & Makris, 2005; Bush, Valera, Seidman, 2005). Similarly, developmental theorists and psychologists working in the field of cognitive psychology have also hypothesized that there are executive function (EF) deficits in individuals with ADHD (Barkley,1997b; Castellanos & Tannock, 2002). Indeed, EF deficits in this population have been confirmed by meta-analysis studies, although neither necessary nor sufficient to cause all cases of ADHD (Willcutt, Doyle, Nigg, Faraone & Pennington, 2005). Specifically, working memory (WM) deficits have been suggested, either alone or in conjunction with other EF processes, as a possible core feature of ADHD (Barkley, 1997b; Rapport, Chung, Shore & Isaacs, 2001). In a recent meta-analysis of WM deficits in children with ADHD, Martinussen, Hayden, Hogg-Johnson, & Tannock (2005) found significant impairment overall compared to controls. Impairment was strongest in spatial tasks and weaker in verbal tasks.

The Stanford Binet-fifth edition (SB-5) is the latest version of the Stanford Binet Cognitive Battery. It includes measures of both verbal and non-verbal working memory. This study is undertaken to examine WM deficits in ADHD children on the SB-5, as well as examine patterns of relative cognitive strengths and weaknesses overall.

Research Problem

The purpose of this study is to add to the body of research regarding the performance of children/adolescents with the three ADHD subtypes on the SB-5, specifically on the Working Memory (WM) and Quantitative Reasoning (QR) factor scores and their related subtests. In particular, this study is interested in patterns of strengths and weaknesses both from a group perspective, as well as within individuals. Furthermore, if such patterns exist, is there utility in these patterns in terms of aiding diagnostic considerations. Based upon these, there are several questions:

Group Difference Approach

Group Difference-Factor Scores:

1) What, if any, differences exist between the five SB-5 factor scores for the three subtypes of ADHD compared to other clinical cases? Is a WM deficit evident across the subtypes?

Group Difference-Subtest Scores:

2) What, if any, differences exist between the four subtest scores comprising the WM and QR factors of the SB-5, for each of the three subtypes of ADHD, compared to other clinical cases? Is the working memory deficit across both verbal and nonverbal areas, as well as all subtypes?

Intra-individual Differences Approach

Difference Score Analysis-Factor Score Level:

3) Is there a difference between each of the three subtypes of ADHD, compared to other clinically referred student, in average difference in their five factor scores on the SB-5?

Difference Score Analysis-Subtest Score Level:

4) Is there a difference between each of the three subtypes of ADHD, compared to other clinically referred student, in average difference in their Non-verbal Working Memory (NVWM), Non-verbal Quantitative Reasoning (NVQR), Verbal Working Memory (VWM), and Verbal Quantitative Reasoning (VQR) subtest scores on the SB-5?

Number Counts

Chi-Square Analysis-Factor Score Level:

5) Is the number of individuals with ADHD exhibiting a significant weakness in the WM or QR factor score greater than other clinical cases? Does any difference occur in all subtypes of ADHD? Does the number of cases of other factors differ?

Chi-Square Analysis-Subtest Score Level:

6) Is the number of individuals with ADHD exhibiting a significant weakness in NVWM, NVQR, VWM and VQR scores greater than other clinical cases? Does any difference occur in all subtypes of ADHD?

Definition of Terms

Throughout this study the following definitions will be used.

Executive Functions

In this study, executive functions (EF) will be defined as a range of cognitive functions, assumed to be located primarily in the prefrontal cortex, that control and regulate various cognitive processes required for purposeful behaviour (Brown, 2002). WM is often included as a component of executive functions.

Working memory will be defined on the SB-5 as the scores on the Nonverbal Working Memory factor (NVWM) and on the Verbal Working Memory factor (VWM); (Roid, 2003c). The NVWM consists of two activities: Delayed Response and Block Span. The VWM consists of two activities: Memory for Sentences and Last Word.

ADHD cases

Diagnosis for ADHD will follow the DSV-IV TR (APA, 2000) diagnostic criteria. Information for the diagnosis will be obtained from the following sources: scores on the Behavior Assessment System for Children (BASC), the Behavior Assessment System for Children, Second Edition (BASC-2), or the Conners' Rating Scales-Revised (CRS-R). Since files contained either the BASC or BASC-2, all subsequent references to the BASC will imply either edition. In addition, a file review for historical evidence of ADHD, clinician's diagnosis, and the Structured Interview (SIDAC-R) will also be used if available. Scores on the BASC will be used to make the initial selection of ADHD subjects. The ADHD-H group will consist of cases with BASC scores of T-scores above 60 on the Hyperactivity scales from either the Teacher Rating Scale (TRS) or Parent Rating Scale (PRS), depending upon availability. The ADHD-I group will consist of cases with a BASC T-score of 60 or higher on the Attention Problems scales on either the TRS or PRS, depending upon availability. The ADHD-C group will consist of cases with elevations for both Hyperactivity and Attention Problem scales from either the TRS or PRS, depending upon availability. Within the preliminary sample of ADHD subjects, historical information will be reviewed to select those who had exhibited some symptoms prior to the age of 7. Where possible, negative impact on the child's home and school settings will be collected from the SIDAC-R. In addition information provided from the school or home, past assessments, or the clinician's findings will also be considered. Those cases with only one source of evidence will not be considered ADHD.

Clinic Control Cases

All cases with a T-score of less than 60 on both the Hyperactivity and Attention Problem scales from either the TRS or PRS, and no past diagnosis or treatment for ADHD will be placed in the clinic control group.

Learning/Cognitive Disorder

All cases with a prior or current diagnosis of a specific learning disorder/disability, or cognitive deficit (FSIQ below 70) will be identified. This information will be taken from either the background or summary sections of the report.

Psychiatric Disorders

All case with a current or previous diagnosis of a DSM-IV Axis I disorder will be identified as having a psychiatric disorder.

CHAPTER 2: SURVEY OF THE LITERATURE

This chapter will begin with an exploration of various theories of the underlying causes of ADHD, including neurological studies supporting the involvement of frontal-cortex dysfunction. This will be followed by a discussion of literature related to the role of executive dysfunction and WM. A brief description of the SB-5, BASC, BASC-2, and relevant research, will follow. This chapter will close with the hypothesis, rational and delimitations of the proposed study.

Theories of Underlying Causes of ADHD

There remains no consensus regarding the underlying cause of ADHD. Diagnosis of the disorder is currently dependent upon identification of the three primary behavioural features of ADHD, inattention, hyperactivity, and impulsiveness (APA, 2000) which are presumed to be caused by either psychosocial or biological factors.

Over the years various psychosocial factors have been suggested for ADHD. These have included poor child-rearing practices, exposure to family violence, posttraumatic stress, and/or learned behaviour (Barkley, 1997a). Possible biological causes have included brain injury due to toxin exposure or trauma, food and environmental allergies, diet, genetic abnormalities, as well as normal genetic variation (Chess, 1960; Levy, Hay, McStephen, Wood & Waldman, 1997). However, psychosocial and non-genetic, biological, factors (such as exposure to toxins or physical trauma) have been found to account only for 10 to 15% of the variance in ADHD symptoms (Goodman & Stevenson, 1989). Familial studies have consistently found a strong linkage between the occurrences of ADHD in first order family members (Biederman, 2005), supporting a strong genetic factor.

Research has now established that there is a strong association between ADHD and neurological dysfunction associated with the prefrontal-striatal areas of the brain (Barkley, 1998). It is believed that there is a fundamental difference between the brain functions of individuals with ADHD and those of "normal" individuals.

Supporting evidence of this has been found from a wide range of cognitive, neurological, biochemical, and psychometrics research. There has been a close association of ADHD and its' symptoms to other neurological based disorders (Barkley, 1997a). These disorders include language and math disabilities (Barkley, 1998), non-verbal learning disabilities, Tourette's syndrome, motor-coordination problems, and poor performance in psychoneurological tests (Barkley, 1997a). ADHD's early onset and life long impact, as well as the similarity of the behavioural patterns of ADHD individuals to the behavioural patterns of brain-injured individuals further strengthens the neurological argument. If there truly is a neurological basis to ADHD, then corresponding dysfunction would be assumed to occur in areas of the brain responsible for attention, executive functioning, including; levels of arousal, and impulse control, as well as the corresponding connections between.

ADHD as a Frontal-Subcortical Disorder

The following section will provide a brief summary of physiological evidence supporting an association between ADHD and dysfunction in the frontal lobe and its' connections to key subcortical regions of the brain (Barkley, 1998;

Biederman, 2005). This supporting evidence comes from literature from pharmacological, neuroimaging, and genetic studies that implicate the noradrenalin (NA) and dopamine (DA) neurotransmitter systems.

Pharmacological Findings

Pharmacological treatment for individuals with ADHD has been widely studied and found effective (Solanto, Arnsten & Castellanos, 2001). Medications effective in treating the symptoms of ADHD implicate involvement of the catecholamine neurotransmitter system, supporting the possible role of a catecholamine dysfunction in ADHD (Pliszka, 2005). There are four general classes of medication that have been studied in the treatment of ADHD: antidepressants, antihypertensives, NA reuptake inhibiters, and DA agonists (Barkley, 2004). Stimulants (DA agonists) are the most commonly used pharmacological treatment prescribed and include methylphenidate and amphetamine. These have been found to be effective in improving symptoms by many randomized, double-blind, placebo-controlled clinical trials (Barkley, 2004; Swanson, et al., 2008a, Solanto, et al., 2001).

Neuroimaging Findings

Evidence from a range of neuroimaging studies has been able to provide further evidence of the involvement of the prefrontal-striatal region of the brain in ADHD. Various advances have allowed researchers to not only study structural differences between ADHD subjects and controls, but also the location of brain activity during different cognitive tasks.

The structural differences between ADHD subjects and controls were first studied using computer tomography (CT) scans, then magnetic resonance imaging (MRI) (Himelstein, Schulz, Newcorn & Halperin, 2000). Numerous neuroimaging studies have indicated that there are measurable differences in the structure of the brains of individuals with ADHD compared to normal individuals (Seidman, Valera, & Markris, 2005). Total cerebral volume has been found to be significantly smaller in subjects with ADHD compared to normal controls (Castellanos, Giedd, Hamburger, Marsh, & Rapoport, 1996; Filipek, et al., 1997). Comprehensive studies of structural differences (Seidman, et al., 2005; Castellanos, et al. 2002) have found structural differences in the volume of various brain structures, including total white and grey matter. However the above results have been inconclusive and marked by conflicting data (see Himelstein, et al., 2000; Hendren, DeBacker, & Pandina, 2000 for review).

Functional brain imaging techniques allows researches to examine brain activity during specific cognitive tasks, and include functional magnetic resonance imaging (fMRI), single photon emission computed tomography (SPECT), and positron emission tomography (PET) (Bush, et al., 2005). Findings suggest functional differences between ADHD subjects and normals in terms of activity in the prefrontal cortex and the striatum (Bush, et al., 2005; Himelstein, et al., 2000). In addition to these differences, a relationship between the degree of symptoms of ADHD and lowered metabolic activity in the left frontal area (Zametkin et al., 1993) and frontal lobe (Yeo, et al., 2003) has also been identified.

Genetic Findings

Genetic studies have also supported the involvement of the frontal-striatum in ADHD symptomatology. Various family, twin and adoption studies have established a strong genetic relationship with ADHD (Aron & Plodrack, 2005). In a recent review, DiMaio, Grizenko, & Joober (2003) argued that the SLC3A6, the dopamine transporter, and DRD4, the dopamine receptor, genes were most consistently associated with ADHD etiology. These genes are associated with the DA system

The prefrontal cortex (PFC) plays a significant role in executive functioning, and has been found to be involved in the suppression of responses to irrelevant events (Casey, et al., 1997). This provides a possible association between this structure and the ADHD trait related to attention and distractibility.

Theories of Executive Dysfunction and ADHD

The evidence from physiological sources, implicating the prefrontal and subcortical structures of the brain, has been supported by findings of processing problems related to EF in individuals with ADHD. EF typically refers to a set of higher order functions necessary problem-solving behaviours which enable goal directed behaviours.

Pennington and Ozonoff (1996) offer a widely accepted set of cognitive operations that include set-shifting, interference control, response inhibition, planning, and working memory.

In the various developmental and cognitive literature concerning ADHD, two major theoretical conceptualizations are those of based upon Rapport, Chung, Shore Denney & Isaacs (2000) WM deficit, and Barkley's (1997a) disinhibition model. Rapport et al applied Baddeley's (1986) WM concept as an explanation of ADHD symptomology.

Baddeley

One of the executive functions that appear to be mediated by the pre-frontal cortex is that of WM (Braver, et al., 1997; Carlson, et al., 1998). WM was postulated by Baddeley and Hitch (1974) as a development from the theoretical construct of short term memory (STM). STM was an attempt to describe the temporary storage of information required for more complex cognitive processing (Baddeley, 2000; Atkinson & Shiffrin, 1968; Phillips, Shiffrin, & Atkinson, 1967), as well as the placement of external sensory information into, and retrieval from, long-term memory (LTM) (Baddeley, 2003). Baddeley's theory grew primarily out of research involving normal and brain injured subjects, but also psychometrics (Baddeley 1996a).

Problems with the idea of a unitary short-term memory arouse however from research involving memory impairment in brain injured patients. The unitary model implied that damage to STM should impact upon long-term learning and common cognitive processing, which was found not to be the case (Baddeley, 2003). In order to explain these findings, Baddeley and Hitch (1974) expanded this concept into a non-unitary model made up of three components instead of one. As with the concept of STM, WM was conceptualized to include functions related to the retention of immediate sensory information. However WM was conceptualized to take a more centralized role on the processing of information rather than simply serving as a form of centralized memory (Baddeley, 2000). Thus, WM was viewed as central to human "reasoning, learning and comprehension" (Baddeley, 2003, p. 829) and frontal lobe function (Baddeley, 1986).

WM's original three major components, as first postulated by Baddeley and Hitch (1974), included a control system, called the Central Executive. The Central Executive served the role of an attention controller, and was aided by two subsidiary storage systems. The Phonological Loop holds short-term, language based information, whereas the Visuospatial Sketchpad does the same with visual information.

The Phonological Loop. The Phonological Loop has been the most studied of the three components of WM (Baddeley, 1996a). The Phonological Loop is responsible for the short-term retention, as well as some limited processing, of verbal and auditory information. It was further divided into two other components by Burgess and Hitch (1999), a Phonological Store and Articulatory Rehearsal Process. The Phonological Store is responsible for the simple storage of information. The Articulatory Control Process is involved in the rehearsal and recoding of auditory information to aid in its retention. Phonological memory traces are believed to be held in the store for only a short period of time (Baddeley, 2003). However, these memory traces can be refreshed by the second component, through Sub-vocal Re-articulation.

The effectiveness of Sub-vocal Re-articulation or Rehearsal can be disruptive, causing the loss of that information, in one of three ways. The first is through articulatory suppression, where an individual is required to repeat a word or sound, thus interfering with rehearsal. Increased length of the word or number of syllables has also been found to interfere with retention. Finally, words that are phonologically similar will interfere with one another.

The Visuospatial Sketchpad. Like the Phonological Loop, the Visuospatial Sketchpad is responsible for the storage and limited processing of visually presented stimuli. It serves as a buffer, retaining visual and spatial information. Like the Phonological Loop, the Visuospatial Sketchpad is also limited in its' capacity (Baddeley, 2003), and stored images quickly fade unless rehearsed.

Again similar to the Phonological Loop, this slave system is divided into two sub components, one responsible for storage, the other for rehearsal and/or manipulation (Logie, 1995). The storage component is called the Visual Cache, which stores visual information. The Inner Scribe is responsible for the rehearsal of spatial information or perceived motion. Baddeley (2003) indicates that the storage capacity of the Visuospatial Sketchpad is four objects, which can be disrupted by similar features such as colour, shape or location.

The two sensory storage systems are considered active stores (Baddeley, 2000), in that they have limited capacity to combine information from either sensory inputs, as well as the central executive (Baddeley, 2000).

The Central Executive. The Central Executive was originally conceptualized as an explanation for the complex processing tasks that did not fit well in either of the sensory stores. It has no storage capacity of its own, but rather is involved in a number of complex tasks, allocating cognitive resources, planning, retrieval and monitoring the processing of information (Baddeley, 1996a). Baddeley (1986) later attempted to refine his theory of the Central Executive in order to incorporate the idea of a Supervisory Activating System (SAS) (Norman & Shallice, 1980). This model attempted to explain slips of actions as well as symptoms observed in patients with frontal lobe injuries who perseverate on some occasions and suffer from distractibility on other (Baddeley, 1996b). The SAS would be active when behaviour could not be controlled by routine and habitual patterns (Baddeley, 2003).

Because the Central Executive coordinates the activities of the two buffers, it also serves a role in attention (Baddeley, 1993; Baddeley, 2003) and in the coordination of information from the two other systems. Baddeley (1996b) suggested that it "provides an interface between perception, attention, memory, and action" (p. 13472).

The Central Executive remains poorly defined and Baddeley himself concedes that over time, further specifics into the various roles it plays may lead to it being divided into other components (Baddeley, 1996a; 2003). Further, the three component model typically presented interactions between the Central Executive and the two slave systems. It did not explain how WM interacted with long term memory (LTM) and the role it played in learning. This was explained initially as intentional, as WM and LTM were viewed as separate. This was likely partially due to research showing that brain injured patients with short-term memory (STM) deficits typically had intact LTM (Baddeley, 2000).

However, research started to challenge the original model in several ways. Research into patients with STM deficits found them to have some limited deficits in long term auditory memory. This suggested that the Phonological Loop was playing some role in long term auditory memory (Baddeley, 2000). Furthermore, research in vocabulary development also indicated that a deficit in the Phonological Loop interfered with the acquisition of word understanding.

Baddeley (2000) suggested that a similar pattern applied to the Visuospatial Sketchpad, although little research into this area has been made.

In order to explain some of the interaction between WM and LTM, it was suggested that information was transferred between the two slave systems and their long term memory equivalents. However other research indicated that at times visually presented, serial information was transferred to the Phonological Loop for transformation into auditory short term memory. For instance, an individual will visually perceive an object, but then aid recall by naming the object, thus utilizing the auditory system. Under the original model, this would have had to occur through the Central Executive, which lacked a storage capacity of its own, and thus was implausible. It was due to this and other difficulties in explaining the transfer of memory traces between short and long term memory that Baddeley introduced the idea of a forth component, the Episodic Buffer (Baddeley, 2000, 2003).

The Episodic Buffer. The Episodic Buffer (Baddeley, 2000) is conceptualized as a temporary information storage system of limited capacity. Its' theoretical purpose is to provides temporary storage of information in a multimodal form, and to combine information from the two subsidiary systems with information from LTM (Repovs & Baddeley, 2006). The combined information takes the form of a unitary episodic representation. Details regarding the Episodic Buffer have not been clearly described thus far in the literature, including how to measure it. However, Baddeley (2000) proposed that the principal mode of retrieval from the buffer was conscious awareness.

Research into the developmental process of WM suggests that the three main components are present in children by age 6, increasing in capacity into adolescence (Gathercole, Pickering, Ambridge & Wearing, 2004).

WM capacity has been shown to impact upon academic achievement, including in the areas of early literacy acquisition, mathematics and science (Gathercole, Pickering, Knight, & Stegmann, 2003). Research has suggested that particularly the Phonological Loop, plays an important role in language development (Baddeley, Gathercole & Papagno, 1998). A weak Central Executive has been implicated in difficulties with literacy skills, vocabulary acquisition and overall academic and career success (see Gathercole, Pickering, et al., 2004 for a review).

Studies have supported the roles of the pre-frontal cortex, hippocampus, as well as the posterior regions of the brain in WM (Rudner & Ronnberg, 2008; Sheridan, Hinshaw, & D'Esposito, 2007).

ADHD and Working Memory

Karatekin (2004) conducted a test of the integrity of Baddeley's model in ADHD children. This study compared ADHD children to controls on tasks measuring the Visuospatial Sketchpad, Phonological Loop and Central Executive. Results found no significant difference between the subjects and controls on simple recall in either the spatial or auditory tasks. However more complicated tasks, requiring dual-task performance were found to be impaired in ADHD children. This supported findings from others (Mariani & Barkley, 1997; McInnes, Humphries, Hogg-Johnson & Tannock, 2003).

A recent meta-analysis (Martinussen, et al., 2005) examined twenty-six studies of WM deficits in children with ADHD. Studies included in this analysis were categorized as requiring verbal and/or spatial tasks, as well as being simple storage or manipulation tasks. Significant spatial storage and Central Executive function deficits, and modest verbal and nonverbal Central Executive deficits were identified in this study. Interestingly, the authors found no significant change in results when digit span tasks (considered a simple storage task) was controlled. Not surprisingly the authors found a moderate degree of inconsistency in the findings, with the exception of verbal storage. The authors' noted that diagnostic criteria, as well as control for comorbid disorders, learning disabilities or language impairments varied widely across studies.

Rapport

Building upon Baddeley's WM model, Rapport, Chung, Shore, and Isaacs (2000, 2001) proposed a conceptual model of ADHD that attempts to differentiate between the core behavioural deficits of ADHD (attention, hyperactivity, and impulsivity) and what they refer to as the neurobiological substrait. In this model Rapport et al. assume that biological influences, such as genetics, lead to differences in the functioning of neurobiological substrates. In turn, the underlying neurological substrates impact upon core cognitive functioning. In the case of ADHD they propose this core cognitive functioning to be WM. They go on to attribute WM dysfunction to the core behavioural features of ADHD; inattention, hyperactivity, and impulsiveness.

Rapport et al. note that WM is responsible for accessing previously formed constructs, matching current events and input with similar ones from past experiences, and making available all related information associated with these. It is through this process that WM influences behaviour. Because of its' role in recognition of external stimulus and in the accessing of past memory traces (retrieval) in order to organize an appropriate response, working memory is seen as having a significant role in an individual's behaviour. It is through this role that Rapport et al. (2001) associates the behavioural symptoms of ADHD with WM deficits. They suggest that WM has a significant role in organizing behaviour in response to stimuli through its functions in generating and maintaining representations of incoming stimuli, searching for memory traces similar to the current stimuli and matching these, and finding and maintaining appropriate behavioural responses to the current stimuli. They argue that any breakdown in these functions would lead to disorganized behaviour found in persons with ADHD. For example, Rapport et al. suggest much of the overactive behaviour seen in persons with ADHD is simply "stimulus seeking" due to failure to adequately maintain mental representations of incoming stimuli. In this way the individual increases the rate of stimulus input into WM. This is often expressed as the diagnostic behaviour of hyperactivity. Problems maintaining effort and attention to monotonous tasks are frequently observed in individuals with ADHD. Rapport et al. conceptualized these situations as ones that involve a low rate of stimulus input. Again, because of their weakness in maintaining a conceptual representation, ADHD individuals escape the discomfort of having to maintain the representation by seeking input elsewhere, leading to an observation of inattention. Inattention arises when the individual is unable to maintain enough details of the current stimuli, and switches their attention in order to escape the resultant discomfort. In this sense the model sees inattention as an aversive avoiding behaviour.

Impulsive behaviour is seen simply as unorganized responses that are a direct result of the weakness in matching current memory traces with appropriate behavioural responses. An individual's poor WM leads to impulsivity due to difficulties processing incoming information and organizing appropriate behaviour. Similarly dysfunction in the ability to maintain representation in working memory, either in the Phonological Loop or Visuospatial Sketchpad, leads to distractibility. This is due to the need to constantly refresh or replace lost memory traces with new ones.

Barkley

Building upon research findings of abnormalities in the structure and function of the prefrontal cortex, Barkley (1997a, 1998) suggested a model that proposes that failure to effectively inhibit behaviour leads to the various symptoms of ADHD. He also included WM in his model of ADHD as part of his overall disinhibition model. In his model, Barkley maintains that dysfunction in the frontal cortex impacts upon an individual's ability to inhibit prepotent responses to stimuli, or disinhibition. This failure to inhibit in turn impacts upon the effective functioning of four executive functions: WM, internalized speech, self-regulation of affect-motivation-arousal, and reconstitution. Dysfunction in these four areas results in difficulty maintaining effective control of internal information processing and impacts upon an individual's ability to direct behaviour effectively and with persistence.

Barkley's (1997a) theory makes a number of predictions related to resulting deficits in WM (p. 77). He argued that due to problems with behavioural disinhibition, individuals will display behaviour that suggests that they are more influenced by immediate context and less by internally represented information, leading to less influence from events or consequences further removed in time. They are less likely to be able to recall effectively and hold information about the past and access it to plan for future events or actions. With this impact upon anticipatory or preparatory behaviours, individuals with ADHD are less likely to be able to anticipate future events and effectively prepare for future events. Problems with behaviour directed by time and organization factors are predicted, as are temporal myopia. Subjects with ADHD should experience deficits in formulation of if-then contingencies due to problems accessing internally represented information. The theory predicts that larger delays in time should result in greater deficits in goal-directed behaviour. Deficits in WM should also be reflected by difficulty repeating sequences of actions demonstrated by others. Poor time awareness and retrospective functioning should result in a tendency for ADHD individual's to refer less often to time, past events, and future plans. Because of the resultant difficulties in supplanting immediate consequences for future social and personal ones, ADHD individuals should display significant difficulties with social skill performance.

Various studies, including one by Stevens, Quittner, Zuckerman & Moore (2002) have found significant deficits in ADHD children in the areas of inhibition, working memory and short-term memory compared to normal.

General Research

A meta-analysis of WM impairments in ADHD children (Martinussen, et al., 2005) found support for WM deficits in ADHD children. Furthermore, the nonverbal WM domains (spatial) showed a greater impairment than verbal domains (Braver, et al. 1997; Carlson, et al., 1998; Martinussen, et al., 2005). In a study of EF in ADHD children, Barnett, et al. (2001) found spatial WM deficits unaffected by the subject's age or the degree of ADHD symptomatology. In both this, and another study by Kempton, et al. (1999), ADHD subjects currently taking stimulant medication did not exhibit this spatial WM deficit. Kempton et al. also found deficits in spatial STM, shifting cognitive sets and planning ability compared to both controls and medicated subjects with ADHD.

Comorbidity and ADHD

Complicating the study of ADHD is the wide range of comorbid disorders commonly associated with it. A range of both learning and psychiatric disorders have been identified as comorbid in children and adolescents with ADHD (Bird, Gould & Staghezza, 1993), with one study identifying up to two thirds of its sample as having at least one other psychiatric diagnosis (Cantwell, 1996). ADHD is frequently associated with a higher than expected rate of comorbid conditions including disruptive (Acosta, Arcos-Burgos, & Muenke, 2004), affective (Biederman, Faraone, Milberger, et al. 1996; Bird et al. 1993, Acosta, et al., 2004), and learning disorders (Dykman & Ackerman, 1991; Shaywitz, Fletcher & Shaywitz, 1995; Willcutt & Pennington, 2000).

Of clinically referred children with ADHD, approximately 60% to 75% present with significant behavioural difficulties (Hinshaw, 1987). Biederman, Newcorn & Sprich (1991) found ADHD comorbid with either Oppositional Defiant Disorder (ODD) or Conduct Disorder (CD) in between 30% to 50% of cases. Although commonly associated, evidence suggests that ADHD and CD are independent (August, Stewart, & Holmes, 1983). Oosterlaan, Scheres & Sergeant (2005) found significant WM deficits, as well as planning abilities, independent of ODD/CD.

Various mood disorders co-occur in children/adolescents with ADHD, with upwards of 10-20% of subjects identified (Goldman, Genel, Bexman, & Slanetz, 1998). Depression is common in this population, occurring in approximately 15% to 75% of cases (Biederman, et al., 1991). Mania has been found to co-occur at a higher rate in ADHD children compared to controls (Biederman, Faraone, Milberger, et al., 1996). Anxiety is another common comorbid condition (Jensen, Shervette, Xenakis, & Richters, 1993). The rate of anxiety disorders in children with ADHD is higher than in controls (Biederman, Faraone, Mick, et al, 1996). Schatz & Rostain (2006), in a recent review of the literature, indicated that comorbid anxiety tends to increase the WM deficits found in children with ADHD.

Given the diagnostic symptoms of ADHD it is not surprising that these alone would result in significant learning difficulties. Comorbid learning disorders have been widely reported in the literature, with the rate ranging from 10% (August, & Holmes; 1984), 30% (Frick, et al. 1991), to over 90% (Silver, 1981). In a recent study, Mayes, Calhoun & Crowell (2000) found 70% of children diagnosed with ADHD had comorbid learning disabilities.

In terms of the impact of comorbid conditions on EF, it has been suggested that comorbidity has served as a confound in past research (Nigg, Hinshaw, Carte, & Treating, 1998). Earlier studies have reported evidence of poorer overall performance on tests of intelligence by children with ADHD (Campbell & Werry, 1986). However, Faraone, et al. (1993) concluded that comorbid conditions had only limited influence on Wechsler Intelligence Scale for Children - Revised (WISC-R) scores. They also concluded that impairments in neuropsychological functioning were due to ADHD and not comorbid psychiatric conditions. Comorbid reading disorders have been found to share common EF deficits (Willcutt, Pennington, Olson, Chhabildas & Hulslander, 2005). However, in this same study, the phonological deficits were found to be unique to the reading disorder group only.

In a study of WM deficits in children with ADHD and reading/language disorder (RD/LI), Martinussen & Tannock (2006) found impairment in WM in the ADHD only, RD/LI only, as well as ADHD/RD/LI groups. However there was some difference in the constellation of WM deficits between groups. The ADHD only group showed deficits in visual-spatial storage, as well as both verbal and visual-spatial central EF independent of comorbid conditions. The RD/LI group showed deficits in all aspects of WM (both storage systems and both Central Executive tasks). Another finding of this study was that impairment in WM was more closely associated with symptoms of inattention than hyperactivity/impulsiveness.

Cattell-Horn-Carroll (CHC) Theory of Cognitive Abilities

The CHC theory of human intelligence is a consensus model derived from two similar theories, the Cattell-Horn Gf-Gc hierarchical model, which in turn evolved from the earlier work of Thurstone's nine primary mental abilities theory and Carroll's three-stratum model (McGrew, 2005). The theory provides a taxonomy for human intelligence, based upon psychometric studies of cognitive abilities utilizing both exploratory and confirmatory factor analysis.

As mentioned above the model is hierarchical in nature, containing narrow abilities (Stratum I), which then load onto between eight to ten broad abilities (Stratum II). These then load onto g (Stratum III), commonly referred to as global intelligence. The validity of the theory and of the makeup of both Stratum III and II abilities have been supported by a large number of studies (McGrew, 2005).

Among the broad abilities (Stratum II) is short-term memory (Gsm). This broad ability is defined in the traditional sense of STM to reflect it as a system of limited capacity in terms of the quantity of information retained and limited temporal span. McGrew (2005) lists MW as a Stratum I ability within this Gsm. He goes on to list the three original components of Baddeley's WM model, as well as the Episodic Buffer, also subsumed under MW. McGrew differentiates WM from the other individual difference constructs however, as most of the other traits underlying the Stratum I abilities were based upon factor analysis. He indicated that MW evolved as a theoretical construct based upon results from experimental research (McGrew, 2005, p.154). In this sense the construct of WM bridges findings from psychometric studies, cognitive processing models, and experimental cognitive research (McGrew, 2005).

Baddeley (2003) also addresses WM's position in the CHC model. To him, all three components of the WM system are part of fluid capacity, and interact with the more crystallized component of LTM.

Various measures of WM have been used in past research. In order to effectively study the role of WM, a test must come as close to direct measurement of the construct as possible, free of confounds. Past weaknesses in some measures have included reliance upon some academic achievement, such as the Arithmetic subtest in the Wechsler series of intelligence tests. Furthermore, many test tasks purporting to measure WM may require only simple storage and repeating of incoming verbal or non-verbal stimuli. Most WM tests have some level of executive demand (a requirement of manipulation of the information stored), as well as cognitive processing requiring the Episodic Buffer (i.e. combining the stored information with past learned knowledge). This executive manipulation of the information stored is often referred to as "executive working memory" (p. 698; Perry, et al., 2001). In addition to identifying the components of WM a test may tap into, measures of WM should specify the domain they measure (spatial or verbal).

Cognitive Measures of Working Memory

Cognitive measures are a major component of assessment protocols used by specialists in the identification and treatment of ADHD children (Dulcan, et al., 1997). In terms of WM, commonly used cognitive batteries that claim to measure this include the Wechsler Intelligence Scale-Fourth edition (WISC-IV), the Woodcock-Johnson III Tests of Cognitive Abilities (WJ-III), and the Stanford-Binet Intelligence Scales, Fifth Edition (SB-5). Of these three, only the SB-5 provided an adequate measure of both the verbal and nonverbal components of WM (Leffard, et al., 2006).

Stanford-Binet Intelligence Scales-Fifth Edition (SB-5)

The SB-5 is an individually administered, standardized and norm referenced measure of cognitive abilities. It is intended for use with subjects ages 2 to over 85 years of age (Roid, 2003c). In its' complete form the scale is comprised of 10 subtests, which together are used to calculate the Full Scale IQ. In addition to the Full Scale IQ, two domain composite scores, Verbal IQ and Nonverbal IQ can be calculated using five of the ten subtests each. Each subtest is purported to measure one of five cognitive factors in either verbal or nonverbal areas.

The development of the SB-5 can be traced back to the work of Binet and Simon in 1908 on identification of cognitive disorders in France and Terman's first edition of the Stanford-Binet in 1916 (Sattler, 2001).

The SB-4 (Thorndike, Hagen & Sattler, 1986) represented a major revision of the scale. In this edition, four factor scores were included, which together made up a general ability score. The four factors were Verbal Reasoning, Abstract/Visual Reasoning, Quantitative Reasoning and Short-term Memory. Only one research article dealing with the SB-4 and ADHD was found. This study compared the SB-4 with the WISC III on a limited number of ADHD subjects, finding full scale scores well correlated. However some difference between the ability estimates and scores indicated some difference between the cognitive abilities measured (Saklofske, Schwean, Yackulic, & Quinn, 1994).

The SB-5 comes with a number of improvements over its' predecessor, the SB-4, including the combination of the age-level format of the Terman and Merril editions of 1937 and 1960, with the point scale formatting of the SB-4

(Sattler, 2001). In addition, routing subtests are used along with functional levels based upon item response theory. According to Roid (2003d) the five cognitive factors measured by the SB- 5 are based upon Carroll, Cattell, and Horn's (CHC) theory of intelligence (Carroll, 1993). This represents a major change for the SB, marking the authors' intent to bring it inline with the CHC model of intellectual abilities. However, the SB-5 did not include all of the CHC factors, most notably Processing Speed (Gs), which has been included in the Wechsler series for both children and adults.

SB-5 Factors

The five cognitive factors measured by the scale are Fluid Reasoning (FR), Knowledge (KN), Quantitative Reasoning (QR), Visual-spatial Processing (VS) and Working Memory (WM). These factors were chosen based upon school achievement research and expert ratings (Roid & Pomplun, 2005). Furthermore each factor was now measured in both verbal and non-verbal domains (Roid & Pomplun, 2005). In regards to this current study, the SB-5 now includes new subtests that measure both verbal and nonverbal WM, as opposed to an emphasis on simple STM as in the SB-4. This is consistent with Baddeley's (1986) WM theory. Table 2.1 presents the five factors of the SB-5 along with the activities associated with the subtests in each of the two domains.

Table 2.1

SB-5 factors and subtests (Roid, 2003c)

Factor	Domain Nonverbal	 Verbal
Fluid Reasoning	Object Series, Matrices	Early Reasoning, Verbal Absurdities, Verbal Analogies
Knowledge	Procedural Knowledge, Picture Absurdities,	Vocabulary
Quantitative Reasoning	Nonverbal Quantitative Reasoning	Verbal Quantitative Reasoning
Visual-Spatial Processing	Form Board, Form Patterns	Position & Direction
Working Memory	Delayed Response, Block Span	Memory for Sentences, Last Word.

SB-5 Subtests

Nonverbal Working Memory (NVWM). NVWM is one of five factor scores measured in the nonverbal domain of the SB-5. It is comprised of two activities, Delayed Response (DR) and Block Span (BS). Examinee may take one or both, depending on the level they begin with and how well they do on the subtest. The DR activity requires the examinee to locate an item after a delay, which has been hidden under one of two to three cups. The second activity, BS, is a block-tapping task. Examinees are asked to reproduce a series of taps on coloured blocks as demonstrated by the examiner. At higher levels of this activity examinees are asked to separate tap sequences into two coloured rows and increasingly longer series of taps. This task is believed to be a nonverbal equivalent to the WISC-IV Digit-Span (Roid & Barram, 2004), measuring the Visual Sketch Pad (Roid, 2003c).

Verbal Working Memory (VWM). VWMF is the verbal equivalent of NVWM of the SB-5. As with that subtest, it is comprised of two activities; Memory for Sentences (MFS) at levels 2 to 3, and Last Word (LW) for levels 4 to 6. In MFS the examinee is required to repeat orally presented phrases or sentences of increasing length, read to them by the examiner. In LW a series of brief questions are read to the examinee, who then must repeat the last word in each question.

Nonverbal Quantitative Reasoning (NVQR). The NVQR subtest comprises various counting tasks involving manipulatables, designed to test emerging quantitative concepts. Items become increasingly difficult and include addition using blocks, number recognition, sequencing and complex mathematical problems.

Verbal Quantitative Reasoning (VQR). VQR begins with object counting tasks, then a number identification and simple addition/subtraction. Items at these levels use pictorial objects and short word problems. More advanced items measure the individual's measurement, geometric, and word problem solving abilities. At the highest levels, the individual in provided with a pencil and paper due to the complexity of the problems.

Both WM indexes (VWM and NVWM) are believed to measure an individual's ability to store either visual or auditory information, and then to process this information in order to recall it in a specific order. According to Roid (2003c), both of the indexes are congruent with Baddeley's (1986) model of WM, thus providing a natural comparison for this study. The inclusion of a nonverbal measure of working memory can be viewed as a strength of the SB-5, as opposed to the WISC-IV, as there is evidence of non-verbal working memory deficits being more unique to ADHD subjects (Mariani & Barkley, 1997).

SB-5 and ADHD

According to the SB-5 Technical Manual (Roid, 2003d), a total of 94 subjects with ADHD were identified in the standardization sample. The mean scores for this sample feel between 1/3 to ½ standard deviations below that of the normative sample overall (Roid, 2003a, 2003d). The WM factor mean score was the only factor identified to fall significantly below the other factor scores (Roid, 2003d).

Marusiak & Janzen (2005) in a recent retrospective study of 46 ADHD subjects and 59 controls, using the SB-5, found that ADHD children's WM Factor score fell significantly lower than other clinically referred children. This study found no such difference between the two groups on the other factors, suggesting that the difference was indeed unique to the WM Factor score. They also found that the ADHD group's WM Factor score was significantly lower than the FR, QR and VS Factor scores, a difference that did not exist in the control group. As with

Roid's (2003d) findings, no such difference existed between WM and KN factor scores however.

At the subtest level, Marusiak & Janzen found that the NVWM score was significantly lower than VWM score in the ADHD group, as opposed to the control group, which was not significant. Major conclusions of this study included that the spatial storage and spatial central executive functioning was impaired in the ADHD subjects, where no such impairment existed for the controls. Furthermore, only modest deficits existed for the verbal storage and verbal central executive WM domain (Marusiak & Janzen, 2005).

In Marusiak & Janzen's study, The ADHD group consisted of students identified with either ADHD-combined or ADHD-inattentive types. Exclude from the study were those students with ADHD-hyperactivity (due to low numbers), or other comorbid conditions. This is problematic as most individuals with ADHD have some form of comorbid condition. Subjects with ADHD but receiving medication were also excluded.

A second study involving ADHD subjects and the SB-5 was conducted by Blashko (2006). Using a similar sample from the same clinic as the Marusiak & Janzen's study, Blashko examined the SB-5 cognitive profile of 29 subjects with ADHD-combined type, compared to 50 controls. Findings were similar to that of Roid (2003d), with no significant difference between the ADHD-combined group and control group in mean FSIQ, NVIQ and VIQ scores. Similar to Marusiak & Janzen's (2005) and Roid's (2003b) results, the mean WM factor score was found to be significantly lower than that of the control group. When divided into the two subtest however, she found that this difference only occurred in NVWM, and not in VWM. As with the previous study, ADHD subjects were excluded from the study group if they had comorbid conditions such as a learning disability, or were taking stimulant medication (Blashko, 2006).

A third study examined the comparative study of special populations' performance on the SB-5 (Roid & Pomplun, 2005). In this study, the researchers utilized a discriminant-function analysis to compare 94 individuals with ADHD to 41 individuals with average IQ and autism. Results from the study showed that the FR and QR factor scores were the best predictors of group membership. However, details regarding how subjects were recruited, the composition of subtypes for ADHD, and the age range were not provided. Furthermore, a breakdown of subtest analysis was not pursued.

A fourth study (Petchers, 2007) examined archival data on a sample of 188 students assessed at the Child and Adolescent ADHD Clinic at Fairleigh Dickinson University. This study examined the utility of the SB-5 in discriminating between ADHD subjects from non-ADHD subjects. Specifically, the study examined the use of the Shared Ability Composite scores (Roid, 2003d).

In this study the author reported statistically significant weaknesses in the ADHD group, compared to a matched control, in FSIQ, as well as VIQ and NVIQ scores (Petchers, 2007). In addition all ten Shared Ability Composites were also significantly lower than the controls. However, a conditional probability analysis failed to find any practical differences in the Shared Ability Composites for the ADHD group. Results from a series of ANOVA's found significant differences between the ADHD and matched controls on all index scores with the exception of QR. Seven of ten subtest scores also showed significant differences, with the exception of NVFR, VQR and NVQR.

As with this current study, Petchers (2007) utilized a clinical sample of children ages 5-18. Unlike this current study, ADHD subjects were matched based upon age, gender, parent level of education and ethnicity. Diagnostic sources were limited to one medical or psychological source. This study did not break ADHD subjects into subtypes.

Wechsler Intelligence Scale for Children-IV

The WISC-IV was published in 2003 and represents the most current edition of this series. As with the SB-5, the WISC-IV is an individually administered, standardized and norm-referenced measure of cognitive abilities for children ages 6 to 16 years of age.

Prior to the current edition, the WISC-III (Wechsler, 1992) had been the most commonly utilized cognitive assessment instrument for children (Reschly, 1997). In addition to providing updated norms, the WISC-IV incorporates a number of significant changes. Many of these changes were meant to bring the WISC-IV in line with current theoretical models of intelligence, specifically those related to CHC theory (Burns & O'Leary, 2004; Flanagan & Kaufman, 2004). This included the elimination of the Verbal and Performance IQ scores, and changes to the subtests that comprise the four Index scores.

Unlike the SB-5, the subtests contained in the Wechsler series had never been developed using a particular theoretical construct of intelligence. Thus there was no specific intent to measure specific cognitive processes such as WM.

However, factorial analysis applied later supported the grouping of subtests into their current configuration (Flanagan, McGrew & Ortiz, 2000).

The WISC-IV is comprised of 15 individual subtests, 10 that are core and are used to calculate the Five Composite Scores. The four Composite Scores are Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI) and Processing Speed index (PSI). The fifth composite score is the Full Scale IQ (FSIQ), which is a considered a measure of the child's over all cognitive ability (Wechsler, 2003a).

Working Memory Index (WMI). The WMI is one of four composite Index scores that comprise the WISC-IV. The name of this Index represents a change from the previous edition of the test, where it was called the Freedom from Distractibility Index (FDI) (Wechsler, 2003b). In addition to the name, changes were made in the composition of the subtests that comprise this Index. Letter-Number Sequencing was added, and the Arithmetic subtest was demoted to the status of supplemental subtest. The subtest Digit Span was retained as in previous editions of the scale.

Digit Span (DS). This subtest is one of two core subtests that make up the WMI of the WISC-IV. It in turn is composed of two parts, Digit-Span Forward (DS-Forward) and Digit-Span Backward (DS-Backward), which are administered in sequence. For DS-Forward the person is asked to repeat an increasingly longer series of numbers which are read orally by the examiner. Like in DS-Forward, DS-Backward requires the person to repeat increasingly longer strings of number, only, in reverse order to which they were read to him/her. Unlike previous editions, separate scores can be obtained for DS-Forward and DS-Backward, in addition to a DS total score.

Letter-Number Sequencing (LN). Also part of the WMI, LN is a new subtest to the WISC-IV, having been adapted from a similar subtest used in the Wechsler Adult Intelligence Scale-III (Wechsler, 2003b). This subtest requires the subject to listen to a mixed, and increasingly longer, series of numbers and letters. The child then recalls and rearranges them so that the numbers are recalled first in ascending order, followed by the letters in alphabetical order.

Arithmetic (AR). AR is a supplemental subtest on the WMI. On this subtest the subject is required to orally solve a series of arithmetic problems of increasing difficulty. AR was a required component of the (FDI) Index on previous editions of the WISC, the WISC-III (Wechsler, 1992). Although solving mathematical problems mentally places demand upon WM, performance on this subtest is also impacted by academic abilities in arithmetic. Unlike its' predecessor on the WISC-III, AR does not provide a time bonus.

Reliability. The strong psychometric properties of the WISC-IV are well established (Zhu & Weiss, 2005). Reliability of the WISC-IV, as presented in the Technical and Interpretive Manual (Wechsler, 2003b) is very good. The average reliability coefficients for the FS IQ are around .97, with the composite scale Indexes ranging from .88 to .94. The average reliability coefficient is around .92 for the WM Index. Although lower, subtest internal consistency coefficients range from.79 for Cancellation, to .90 for Letter-Number Sequencing. Average test-retest stability coefficients are also very good, with FS IQ around .93, and WM averaging .89.

Validity. A number of factor analytic studies are provided to support of the validity of the WISC-IV's four structure (Wechsler, 2003b).

ADHD and WISC-IV. Research on the profiles of children administered the Wechsler Intelligence Scales for Children, Third Edition (WISC-III) have found significant patterns in the performance variations between those with and without ADHD. In particular, weakness in FD Index scores, compared to FSIQ has been noted in several studies (Mayes & Calhoun, 2004; Mayes, Schwean & Saklofske, 2005). Research involving adults with ADHD using the WAIS-III, which has a similar subtest composition to the WISC-IV, has also identified significant weakness between WM and other index scores (Lacene, 2003). In a recent study, Mayes and Calhoun (2006) found that all ADHD children scored lowest on the WMI or PSI and noted that the WISC-IV may be more helpful in diagnosing ADHD than the WISC-III.

Although the WISC-IV and its' precursors were never intended to be used to identify ADHD in children, the test has been an important component in assessment of this population. Aside from the importance of determining a child's intellectual capacity in program planning, the factor scores provided by the WISC-IV may be useful in understanding processing differences, particularly in Working Memory, in specific populations including ADHD.

Behavioural Measures

Behavior Assessment System for Children

The Behavior Assessment System for Children (BASC; Reynolds, Kamphaus, 1992) is an omnibus, comprehensive behavioural rating system intended to describe the behaviours and emotions of individual children ages two years, six months to eighteen years, eleven months of age. The BASC measures 11 to 14 dimensions of behaviour measured by three inventory scales, the Teacher Rating Scale (TRS), and Parent Rating Scale (PRS), and the Self-report of Personality (SRP). The TRS and PRS each come in three age based forms, preschool (ages 2 years, 6 months to 5 years, 11 months), child (ages 6 to 11 years), and adolescent (ages 12 to 18). The SRP comes in two forms, the SRP-C for children ages 8 to 11, and SRP-A for ages 12 to 18.

The TRS is designed to measure adaptive and maladaptive behaviours, and is completed by the child's teacher or other qualified professional working with him/her. The three forms on the TRS contain 109, 148 and 138 items respectively. These items are divided into five composite area: Adaptive Skills, Externalizing Problems, Internalizing Problems, School Problems, and Other Problems. These composites are further divided into fourteen scales (see table 2.1). Each item describes specific behaviours, which the respondent rates as occurring on one of four-points, "Never", "Sometimes", "Often", and "Almost Always". Table 2.2 lists the scales of the BASC-TRS, along with the composite scores they contribute to.

The PRS contains between 126 to 138 items, which comprise the four composites types: Adaptive Skills, Externalizing Problems, Internalizing Problems, and other problems. These are subdivided into twelve scales: Adaptability, Anxiety, Aggression, Attention Problems, Atypicality, Conduct Problems, Depression, Hyperactivity, Leadership, Social Skills, Somatization, and Withdrawal (see table 2.2). As with the TRS, parents or guardians are requested to rate the frequency of specific behaviours across a four point scale.

Table 2.3 lists the scales of the BASC-PRS, along with the composite scores they contribute to.

Table 2.2.

BASC-Teacher Rating Scale components

Composites	Scales
Adaptive Skills	Adaptability
	Leadership
	Social Skills
	Study Skills
Externalizing Problems	Aggression
	Hyperactivity
	Conduct problems
Internalizing Problems	Anxiety
	Depression
	Somatization
School Problems	Attention Problems
	Learning Problems
Other Problems	Atypicality
	Withdrawal

The SRP, a self-report questionnaire, contains ten clinical (Attitude to School, Attitude to Teachers, Sensation Seeking, Atypicality, Locus of Control, Somatization, Social Stress, Anxiety, Depression, and Sense of Inadequacy) and four adaptive scales (Relations with Parents, Interpersonal Relations, Self-Esteem, and Self-reliance). Question items contain statements to which the subject either endorses (true) or does not (false).

Table 2.3.

BASC-Parent Rating Scale components

Composites	Scales
Adaptive Skills	Leadership
	Social Skills
Externalizing Problems	Aggression
	Hyperactivity
	Conduct problems
Internalizing Problems	Anxiety
	Depression
	Somatization
Other Problems	Atypicality
	Attention Problems
	Withdrawal

All raw scores on the BASC are converted to t-scores (mean of 50, standard deviation of 10). Scores are considered to be "Clinically Significant" when they fall two standard deviations above average.

The various BASC scales have been used in a number of studies involving subjects with ADHD. In terms of its' diagnostic utility for ADHD, a number of studies have supported its use (Davis, 2001; Jarratt, Ricco, Siekierski, Becky, 2005; Manning & Miller, 2001; Ostrander, Weinfurt, Yarnold, & August, 1998). However the BASC's utility for differentiating between subtypes of ADHD is considered more limited (Ostrander et al., 1998). The SRP has been used in research of ADHD children (Baxter, 2000; Wootten, 1999).

BASC-2

The BASC-2 is the second edition of the BASC (Reynolds & Kamphaus, 2004). As with its' first edition, the measure is described as a multi-dimensional behavioural and self-perception measure that collects information from a number of sources. The system is intended to provide information to aid in differential diagnoses and educational classification (Reynolds & Kamphaus, 2004).

Changes made to the second edition included addition of a Parenting Relationship Questionnaire (PRQ), a Self-report of Personality (SRP) form for ages 6 to 7, and a Portable Observation Program. Impacting upon this study is the improved reliability and use of updated norms. Items were changed to more closely match DSM-IV-TR diagnostic criteria for specific clinical populations such as ADHD, ODD, and mood disorders. There was also greater similarity of item contents between the PRS and TRS forms (Reynolds & Kamphaus, 2004).

Hypothesis

If WM deficits are one of the core salient problems with ADHD children, is it unique to children with ADHD, or a generalized problem with clinically involved children? Furthermore, is this weakness consistent between the subtypes of ADHD? Is the WM deficit domain specific (i.e. verbal, non-verbal)? Lastly, are WM deficits the only cognitive deficits for children with ADHD when compared to other clinically referred children?

The SB-5 is unique in providing two domain specific measures of WM (Leffard, et al., 2006). Thus it allowed the examination of the two broad domains (verbal, nonverbal) of WM within the ADHD subtypes and other clinical cases.

In this study, WM deficits were examined from two perspectives. The first was a between-group analysis of mean scores. The second examined relative weakness within each individual, using an intra-individual approach. That is, the study defined a WM deficit as a relative weakness compared to overall cognitive profile. This was calculated at both the factor score and subtest score levels. For the factors scores level, it is the difference between the WM factor score and the overall average of the five factor scores. At the subtest score level, this difference was examined within each domain, Verbal and Non-verbal. For the Non-verbal domain it is the difference between the NVWM subtest score and the average of the five non-verbal subtest scores. For the verbal domain, it is the difference between the VWM subtest score and the average of the five verbal subtest scores.

The intra-individual perspective involved analyses of group differences (ANOVAs) based on the size of the relative difference scores and measures of relative frequencies (chi-square) where the number of cases meeting a cut-off score is tabulated.

In addition to the WM factor, QR is the other factor that is most likely to be negatively impacted by a WM deficit. Thus, the same series of analysis was completed on the QR scores.

For the issue of comorbid conditions in ADHD subjects, there is continuing debate regarding the inclusion or exclusion of comorbid cases when studying ADHD. There is argument that studies of ADHD should only examine cases with no comorbid conditions. However, these cases are atypical, as ADHD is typically comorbid with other conditions, such as learning disabilities or behavioural problems. The use of "pure" samples of children with ADHD, although scientifically rigorous, may not generate results that are applicable to "real world" cases of children with ADHD due to the normally high rate of comorbidities in ADHD samples. For this study, cases with comorbid conditions will be included in the analysis. In general, it is hypothesized that the number of comorbid conditions will have a negative effect upon the overall cognitive profile. This will result in a dampening or lowering of cognitive scores at the group level. However, there is no evidence to suggest that this will have a differential impact of different comorbid condition upon specific subtest scores. Thus, there should be no impact for the analysis at the intra-individual level.

The following hypothesises were tested by this study. The hypotheses are organized by the focus of analysis, between group comparisons of mean scores and intra-individual comparisons of relative weaknesses. Within each focus, they are grouped into ADHD subtypes collapsed (ADHD-collapsed), and ADHD subtypes (ADHD-combined, ADHD-inattentive, and ADHD-hyperactive).

Group Difference-Factor Scores

ADHD-collapsed

Hypothesis 1.1.1: There will be no significant difference among the average WM factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.1.2: There will be no significant difference among the average FR factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.1.3: There will be no significant difference among the average KN factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.1.4: There will be no significant difference among the average QR factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.1.5: There will be no significant difference among the average VS factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

ADHD-Combined

Hypothesis 1.2.1: There will be no significant difference among the average WM factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.2.2: There will be no significant difference among the average

FR factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.2.3: There will be no significant difference among the average KN score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.2.4: There will be no significant difference among the average QR factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.2.5: There will be no significant difference among the average VS score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

ADHD-Inattentive

Hypothesis 1.3.1: There will be no significant difference among the average WM factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.3.2: There will be no significant difference among the average FR factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.3.3: There will be no significant difference among the average KN factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.3.4: There will be no significant difference among the average QR factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.3.5: There will be no significant difference among the average VS factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

ADHD-Hyperactive

Hypothesis 1.4.1: There will be no significant difference among the average WM factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.4.2: There will be no significant difference among the average FR factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.4.3: There will be no significant difference among the average KN factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.4.4: There will be no significant difference among the average QR factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 1.4.5: There will be no significant difference among the average VS factor score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Group Difference-Subtest Scores

ADHD-collapsed

Hypothesis 2.1.1: There will be no significant difference among the average NVWM subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 2.1.2: There will be no significant difference among the average NVQR subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 2.1.3: There will be no significant difference among the average VWM subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 2.1.4: There will be no significant difference among the average VQR subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

ADHD-combined

Hypothesis 2.2.1: There will be no significant difference among the average NVWM subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 2.2.2: There will be no significant difference among the average NVQR subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 2.2.3: There will be no significant difference among the average VWM subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 2.2.4: There will be no significant difference among the average VQR subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

ADHD-inattentive

Hypothesis 2.3.1: There will be no significant difference among the average

NVWM subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 2.3.2: There will be no significant difference among the average NVQR subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 2.3.3: There will be no significant difference among the average VWM subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 2.3.4: There will be no significant difference among the average VQR subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

ADHD-hyperactive

Hypothesis 2.4.1: There will be no significant difference among the average NVWM subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 2.4.2: There will be no significant difference among the average NVQR subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 2.4.3: There will be no significant difference among the average VWM subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 2.4.4: There will be no significant difference among the average VQR subtest score of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Intra-individual Differences-Factor Score Level

ADHD-collapsed

Hypothesis 3.1.1: There will be no significant difference among the average difference score of the WM factor of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 3.1.2: There will be no significant difference among the average difference score of the QR factor of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

ADHD-combined

Hypothesis 3.2.1: There will be no significant difference among the average difference score of the WM factor of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 3.2.2: There will be no significant difference among the average difference score of the QR factor of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

ADHD-inattentive

Hypothesis 3.3.1: There will be no significant difference among the average difference score of the WM factor of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 3.3.2: There will be no significant difference among the average difference score of the QR factor of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

ADHD-hyperactive

Hypothesis 3.4.1: There will be no significant difference among the average

difference score of the WM factor of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 3.4.2: There will be no significant difference among the average difference score of the QR factor of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Intra-individual Differences-Subtest Score Level

ADHD-collapsed

Hypothesis 4.1.1: There will be no significant difference among the average difference score of the NVWM subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 4.1.2: There will be no significant difference among the average difference score of the NVQR subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 4.1.3: There will be no significant difference among the average difference score of the VWM subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 4.1.4: There will be no significant difference among the average difference score of the VQR subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

ADHD-combined

Hypothesis 4.2.1: There will be no significant difference among the average difference score of the NVWM subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 4.2.2: There will be no significant difference among the average

difference score of the NVQR subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 4.2.3: There will be no significant difference among the average difference score of the VWM subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 4.2.4: There will be no significant difference among the average difference score of the VQR subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

ADHD-inattentive

Hypothesis 4.3.1: There will be no significant difference among the average difference score of the NVWM subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 4.3.2: There will be no significant difference among the average difference score of the NVQR subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 4.3.3: There will be no significant difference among the average difference score of the VWM subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 4.3.4: There will be no significant difference among the average difference score of the VQR subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

ADHD-hyperactive

Hypothesis 4.4.1: There will be no significant difference among the average difference score of the NVWM subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 4.4.2: There will be no significant difference among the average difference score of the NVQR subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 4.4.3: There will be no significant difference among the average difference score of the VWM subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Hypothesis 4.4.4: There will be no significant difference among the average difference score of the VQR subtest of the three study groups (ADHD-severe, ADHD-moderate, clinic control).

Chi-square Analysis-Factor Score Level

ADHD-collapsed

Hypothesis 5.1.1 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the WM scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 5.1.2 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the QR scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

ADHD-combined

Hypothesis 5.2.1 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the WM scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 5.2.2 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the QR scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

ADHD-inattentive

Hypothesis 5.3.1 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the WM scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 5.3.2 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the QR scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

ADHD-hyperactive

Hypothesis 5.4.1 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the WM scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 5.4.2 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the QR scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Chi-square Analysis-Subtest Score Level

ADHD-collapsed

Hypothesis 6.1.1 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the NVWM scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 6.1.2 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the NVQR scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 6.1.3 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the VWM scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 6.1.4 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the VQR scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

ADHD-combined

Hypothesis 6.2.1 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the NVWM scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 6.2.2 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the NVQR scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 6.2.3 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the VWM scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 6.2.4 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the VQR scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

ADHD-inattentive

Hypothesis 6.3.1 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the NVWM scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 6.3.2 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the NVQR scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 6.3.3 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the VWM scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 6.3.4 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the VQR scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

ADHD-hyperactive

Hypothesis 6.4.1 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the NVWM scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 6.4.2 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the NVQR scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 6.4.3 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the VWM scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypothesis 6.4.4 There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on the VQR scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control).

Hypotheses Statement Summary

The following two tables summarizes the hypotheses discussed above and each associated ADHD study group and SB-5 measures. Table 2.4 summaries the hypotheses relating to group mean differences on the SB-5 measures. Table 2.5 summarizes the hypotheses relating to the intra-individual approach.

Table 2.4

Summary of Hypothesis Statement of group mean differences, by study groups and SB-5 measures

Hypothesis	ADHD Group	SB-5 Measures
1.1.1 to 1.1.5	ADHD-collapsed	WM, FR, KN, QR, VS
1.2.1 to 1.2.5	ADHD-combined	WM, FR, KN, QR, VS
1.3.1 to 1.3.5	ADHD-inattentive	WM, FR, KN, QR, VS
1.4.1 to 1.4.5	ADHD-hyperactive	WM, FR, KN, QR, VS
2.1.1 to 2.1.4	ADHD-collapsed	NVWM, NVQR, VWM, VQR
2.2.1 to 2.2.4	ADHD-combined	NVWM, NVQR, VWM, VQR
2.3.1 to 2.3.4	ADHD-inattentive	NVWM, NVQR, VWM, VQR
2.4.1 to 2.4.4	ADHD-hyperactive	NVWM, NVQR, VWM, VQR

Table 2.5

Summary of Hypothesis Statement related to intra-individual differences, by study groups and SB-5 measures

Hypothesis	ADHD Group	SB-5 Measures
3.1.1 and 3.1.2	ADHD-collapsed	DWM and DQR
3.2.1 and 3.2.2	ADHD-combined	DWM and DQR
3.3.1 and 3.3.2	ADHD-inattentive	DWM and DQR
3.4.1 and 3.4.2	ADHD-hyperactive	DWM and DQR
4.1.1 to 4.1.4	ADHD-collapsed	DNVWM, DNVQR, DVWM, DVQR
4.2.1 to 4.2.4	ADHD-combined	DNVWM, DNVQR, DVWM, DVQR

4.3.1 to 4.3.4	ADHD-inattentive	DNVWM, DNVQR, DVWM, DVQR
4.4.1 to 4.4.4	ADHD-hyperactive	DNVWM, DNVQR, DVWM, DVQR
5.1.1 to 5.1.2	ADHD-collapsed	Counts for WM and QR
5.2.1 to 5.2.2	ADHD-combined	Counts for WM and QR
5.3.1 to 5.3.2	ADHD-inattentive	Counts for WM and QR
5.4.1 to 5.4.2	ADHD-hyperactive	Counts for WM and QR
6.1.1 to 6.1.4	ADHD-collapsed	Counts for NVWM, NVQR, VWM, VQR
6.2.1 to 6.2.4	ADHD-combined	Counts for NVWM, NVQR, VWM, VQR
6.3.1 to 6.3.4	ADHD-inattentive	Counts for NVWM, NVQR, VWM, VQR
6.4.1 to 6.4.4	ADHD-hyperactive	Counts for NVWM, NVQR, VWM, VQR

Rationale

The SB-5 is a relatively new cognitive measure. Past studies using the SB-5 on ADHD students have demonstrated WM deficits. However past studies have either chosen specific subtypes or have collapsed the subtypes together. In addition, none of the studies have examined the WM deficit using the intra-individual approach. Finally, the results of this study will add to the body of research into working memory deficits in individuals with ADHD.

Limitations and Delimitations of the Study

Limitations

Archival studies are limited by the amount and accuracy of the information that had been collected. To the extent that some crucial information might be missing, there are no provisions to amend that. All the assessments were completed by clinicians in training and thus the quality of the assessment and conclusions would vary.

Other limitations of the study include the use of the BASC, BASC-2, or Conners to identify core symptoms of ADHD.

Delimitations

Delimitations of this study include the use of a clinic population. The study population is a convenience sample, those children that had been referred to the University of Alberta Education Clinic. It is suspected that the types of subjects referred to the Clinic tends to under represent the more severely affected cases which would normally be referred for assessment either through the school or health services systems. A further delimitation to using this population of subjects is the fact that it is not randomized, the clinic control group does not represent "normal" subjects, and the full range of children with ADHD is likely not represented. Further, an age restriction was implemented for this study to school aged subjects.

Because of the nature of the measurements used, conclusions can only be attributed to the general construct of WM, as it is measured by the SB-5, as opposed to specific components such as Central Executive, Episodic Buffer, Phonological Loop, or the Visuospatial Sketchpad.

CHAPTER THREE: METHODOLOGY

In order to address the purpose of the study provided in Chapter 1 and test the hypotheses formulated at the end of Chapter 2 a retrospective comparative study using archival data from the University of Alberta Education Clinic was conducted. In this chapter a description of the procedures followed will be provided. First, the measures used will be reviewed, followed by a description of the selection criteria and method used for group assignment of subjects. The statistical procedures used for the study will then be described.

Measures

Stanford-Binet Intelligence Scale-Fifth Edition (SB-5)

The SB-5 is the most recent edition of the Stanford-Binet Intelligence Scale (Roid, 2003a & e). Some limited information on this scale has already been presented in chapter 2. The review in this chapter will present, in greater detail, each of the SB-5 factors as well as the four selected subtests.

The FR factor is believed to measure an individual's ability to solve new problems using either deductive or inductive reasoning (Roid, 2003c). In order to complete the tasks presented in the two KN factor subtests, an individual must pull upon their accumulated pool of general knowledge that they have collected from their environment. QR requires an understanding of underlying mathematical concepts and the application of these to solve verbal and nonverbal problems. VS measures an individual's ability to identify, analyze, and manipulate objects or to explain visual relationships and give directions related to visually presented material. Finally, WM measures an individual's ability to store information briefly, then sort or otherwise manipulate it. As with all factor scores, tasks are included that measure this ability in both verbal and nonverbal domains.

The four subtest of particular interest in this study were NVWM, VWM, NVQR and VQR. These have been reviewed in chapter 2.

As part of the standardization process, reliability studies were conducted for the SB-5 (Roid, 2003a). Internal-consistency reliability for IQ scores were excellent, ranging from a low of .95 to .98. The five Factor Index scores also exhibited excellent reliability scores, ranging from .90 to .92. Split-half reliability for WM was .92. At the subtest level, across all age groups the split-half reliability ranged from .84 to .89, with NVWM being the strongest of the nonverbal subtests (.88). Although VWM showed the weakest reliability (.84) of the verbal subtests, the reliability is still in the very acceptable range.

The validity of the WM subtests of the SB-5 has been supported through criterion-referenced item mapping and convergent and divergent correlations with similar verbal and non-verbal WM measures (Pomplun & Custer, 2005).

BASC/BASC-2

Two versions of the BASC, the BASC and BASC-2, were utilized by the clinic during the period of time the archival data was collected. These versions had been presented in chapter 2. For this study two of the scales, the PRS and TRS, were used to help identify ADHD cases and controls. Elevations on the "Hyperactivity", "Attention" or both, of either 60-69 ("at-risk") or 70 and above ("clinically significant"), were of interest.

In addition other index scores where used to determine the presence and severity of comorbid conditions. These included the "Atypicality", "Somatization", "Conduct" and "Aggression", "Depression", "Withdrawal" and "Anxiety" indexes on the Parents and Teacher Scales.

The BASC and BASC-2 provide two sets of norms, one of which is gender specific, the other is combined. However, the reports were not consistent in using one set or the other in reporting scores. When available, scores based upon gender norms were used.

Reliability. Generally, the reliability of all three scales of the BASC is good. Internal consistency of the TRS was quite good, averaging in the .80's across the three age forms. The Hyperactivity and Attention scales ranged in the high .80's to low .90's. Interestingly, Conduct problems for females ages 6-7 had the lowest internal consistency (.48). Internal consistency of the PRS was notably lower, falling in the upper .70's. However only the Adaptability, Conduct Problems, Hyperactivity and Somatization scales fell below .80. Based upon the manual the medial SRP internal consistency scores for the fourteen scales was .81, ranging from .61 (Self-reliance) to.88 (depression). Test-retest reliability ranges between the three scales. The manual reported good test-retest reliability for the TRS, with median coefficients of .89, .91, and .82 for the three age groups. The PRS was higher, ranging from .82 to .91. Test-retest reliability varied considerably for the SRP, from .05 to .74 for 7-month stability. Inter-rater reliability was reported as good for the TRS and moderate for the PRS, ranging from .60-.91 and .46-.67 respectively. In terms of the Hyperactivity and Attention scales, Inter-rater reliability ranged from .56 to .73 for the PRS and .54 to .75 for the TRS.

Validity. Evidence of validity for the three BASC scales is derived from both factor analysis and correlation studies with similar scales. Factor-analysis provides evidence supporting the three factors of externalizing, internalizing, and adaptive on the TRS and PRS (Reynolds & Kamphaus, 1992), as well as for School Maladjustment (Attitude to School, Attitude to Teachers, and Sensation Seeking). Clinical Maladjustment (Atypicality, Locus of Control, Somatization, Social Stress, and Anxiety), and Personal Problems (Relations with Parents, Interpersonal Relations, Self-Esteem, and Self-Reliance) on the SRP.

Criterion validity for the PRS is supported through correlation studies with a number of parent rating scales including the Child Behavior Checklist (Achenbach, 1991), PIC-R, and Conners Child, ranging considerably between the various scales. Overall validity is weak for preschool ages (Sandoval, 1998). Reynolds & Kamphaus (1992) report positive results for the TRS in correlation with similar teacher report scales. SRP was supported by correlation studies with the Achenbach Youth Self-Report (Achenbach, 1991), Behavior Rating Profile (Brown & Hammill, 1983).

Structured Interview for the Diagnostic Assessment of Children-Revised

In many of the cases reviewed, the clinic utilized the Structured Interview for the Diagnostic Assessment of Children-Revised (SIDAC-R) for clinical interviews with caregivers and teachers of children referred for assessment. The SIDAC-R is made up of standard questions related to various DSM-IV symptoms. Caregivers/teachers rate the absence (no) or presence (yes) of these symptoms (Kamphaus & Frick, 2002).

Conners' Rating Scales-Revised

Some cases reviewed for this study utilized the Conners' Rating Scales-Revised (CRS-R), instead of the BASC, in order to assess ADHD and related behavioural problems in the child. The CRS-R's primary use is in the assessment of ADHD, with items matched to the DSM-IV diagnostic criteria (Conners, 1997). As with the BASC and BASC-2, the CRS-R consists of three scales, parent (CPRS-R), teacher (CTRS-R), and Conners-Wells Adolescent Self-Report Scales (CASS) (Conners, 1997). For this study response scores from the CTRS-R and CPRS-R were used.

Discriminant validity for the teacher form was based upon a sample of 154 children diagnosed with ADHD. Discriminant validity for the parent form was based upon a sample of 91 children diagnosed with ADHD. Results showed significant differences between ADHD and non-ADHD children on the ADHD/DSM-IV scales (Conners, 1997).

Elevations of 60 or above on either DSM-IV Inattentive or DSM-IV Hyperactive-Impulsive were of interest, and used to determine study group assignment.

Design

As mentioned earlier, this was a between group comparison study examining cognitive score differences on the SB-5 between clinically referred children with ADHD and others. The study has three components. The first component examined group mean differences of SB-5 measures between each of the three ADHD subtypes and the clinic control group. The second component examined intra-individual differences for two factors (WM and QR) and their respective subtests (NVWM, NVQR, VWM, and VQR). The third component examined absolute numbers of subjects in each group identified with significant relative difference (weakness or strength) in the two factor and four subtest scores.

Population

This study utilized a convenience sample of students referred for assessment at the University of Alberta Education Clinic located in Edmonton, Alberta, that have been administered the SB-5. This clinic provides services to the community and school systems and is used as a training facility for graduate students in a variety of specializations, such as school psychology and counselling. The time period is restricted by the publication of the scale and its introduction for use by the clinic, which began in the spring of 2003, and included all such files to the winter term of 2007. SB-5 files were further reviewed for the inclusion of the BASC, SIDAC-R, Conners, or other behavioural measure. A total of 451 files were identified.

Sample Size and Case Selection

Of the 451 files reviewed, a total of 173 cases were excluded, 110 due to the age exclusion variable (younger than age 7 or at or older than 18), and 63 due to other factors as follows: FSIQ less than 70, incomplete/abbreviated/prorated SB-5 scores, or lack of a behavioural rating by an adult using the BASC/BASC-2 or Conners (see table 3.1).

Table 3.1

Distribution of excluded cases by academic year and criteria.

Criteria/Year	2003 Spring /Summer	2003-2004	2004-2005	2005-2006	2006-2007	Total
Too young	11	7	15	9	13	55
Too old	16	10	7	3	19	55
FS<70	4	7	5	4	12	32
Incomplete	2	5	5	5	0	17
No BASC	4	4	2	2	2	14
Total	37	33	34	23	46	173

In total, 278 archival files met the initial inclusion criteria, the distribution of these cases, by year, were as follows: 68 (2003 spring/summer), 76 (2003-2004 year), 70 (2004-2005 year and 2005 spring/summer), 22 (2005-2006 year), 42 (2006-2007 year).

Informed consent for use in research was obtained at the time of assessment from all participants in this study and no participants were recruited specifically for the study. The researcher had no contact with the participants. The study met ethics criteria, and received approval from the Faculties of Education, Extensions and Augustana Research Ethics Board.

Study Group Selection Procedure

Following the data collection stage, selected files were reviewed by two registered psychologists (one being the primary researcher), to determine group membership for the study. Because of inconsistencies between the type of information provided in the assessment reports and files, determination of inclusion of cases in either the ADHD or non-ADHD groups required the examination of a range of evidence contained in the files. To be considered to meet this study's criterion for ADHD, a subject must have had more than one source of evidence of ADHD.

Stage I-Initial Criterion Review

A total of six primary criterions were used for the first stage in the group selection and classification process. This process utilized three broad types of information: background information, quantitative measures and qualitative information from the assessment process. Table 3.2 outlines the different criterion considered for Stage I of the grouping process:

Table 3.2

Classification Criterions utilized in Stage I Grouping

Criterion	Indicator
1	Past diagnosis of ADHD
2	Indication of ADHD medication use
3a	T-score of 60 or higher on the BASC/BASC-2 Hyperactivity or Attention scales from the Parent Form
3b	T-score of 60 or higher on the BASC/BASC-2 Hyperactivity or Attention scales from the Teacher Form
3c	T-score of 60 or higher on the Conners DSM-Inattention or Hyperactivity-Impulsivity scales from the Parent Form

3d	T-score of 60 or higher on the Conners DSM-Inattention or Hyperactivity-Impulsivity scales from the Teacher Form
3e	Identification of ADHD on the SIDAC-R
4	Conclusions from the clinician regarding the diagnosis of ADHD or attention problems

At this stage it became apparent that some of the files did not contain all of the eight sources of information. In particular, some cases used the BASC or BASC-2, and others used the Conners. Table 3.3 indicates the percentage of files that did not contain information from those stated sources.

Table 3.3

Percentage of files missing specific information used for initial group selection

Criterion	Cases	Percentage (out of 278)
1) Past Diagnosis	22	7.9
2) ADHD Medications	17	6.1
3) Parent BASC	43	15.5
4) Teacher BASC	86	30.9
5) Parent Conners	257	92.4
6) Teacher Conners	261	93.9
7) SIDAC-R	160	57.6
8) Clinician Conclusion	171	61.5

Placement in initial groupings was based on the following four sources of information: BASC/Conners score, whether or not there was a previous diagnosis and/or medication, an elevation on the SIDAC-R for ADHD and its' subtypes, and any clinician's conclusion of ADHD.

BASC scale scores on Attention or Hyperactivity were used to form three levels of BASC groups: BASC score ≥70, scale score between 69-60, or scale score below 60. For example, an individual with an Attention score of 69, and Hyperactivity score of 58 would be placed in the BASC 60-69 group. An individual with an Attention score of 72, and Hyperactivity score of 61, would be placed in the BASC ≥ 70 group. In cases where the Conners were used, scores on the DSM-IV Inattentive and DSM-IV Hyperactive-Impulsive were substituted.

Based upon these levels of evidence, subjects were assigned to one of 12 possible initial groups, labelled A-L, as indicated in Table 3.4 below.

Table 3.4

Stage I Evidence Criteria and Initial Grouping Categories with numbers of subjects

Criterion	BASC/Conn. >70	BASC/Conn. 60-69	BASC/Conn. <60	Total
Previous Diagnosis/Medication	A (34)	B (24)	C (8)	66
Positive ADHD score on SIDAC-R	D (20)	E (19)	F (5)	44
Clinician's conclusion of ADHD	G (10)	H (7)	I (1)	18
No other evidence of symptoms	J (33)	K (55)	L (62)	150

Total	97	105	76	278

Stage Two-Placement into Study Groups

The initial groups were then combined into one of four groups: ADHD-severe, ADHD-moderate, clinic control, and excluded.

The ADHD-severe group was conceptually viewed as children who exhibited very strong symptoms related to ADHD according to the behavioural questionnaire used in their assessment (typically the BASC, BASC-2, or Conner's), at the time of testing. The ADHD-moderate group consisted of children who were considered to meet the criteria of ADHD, but whose symptoms were not as severe. Subjects placed into the clinic control group did not have any evidence of ADHD in the four categories (BASC score, Previous diagnosis/medication, evidence on the SIDAC-R, clinician's conclusions). Subjects who fell in any of I, J, or K initial selection groups were excluded from the study as these cases contained some evidence of ADHD, but only from a single source. Thus they failed to meet this study's criteria for placement in either an ADHD study group or the clinic control group.

The four study groups thus consisted of subjects from the initial groups as indicated in table 3.5. Initial Group F was included in the ADHD-moderate even though the BASC scores were below 60. It was decided that in order to score as ADHD on the SIDAC-R, symptoms had to be observed in multiple settings. Thus this satisfied the criteria for multiple sources of evidence.

Table 3.5

Study Groups and number of subjects

Study Group	Initial Grouping	Cases
ADHD-severe	A, D,G	64
ADHD-moderate	B, C, E, F, and H	63
Clinic Control	L	62
Excluded	I, J, K	89

Exclusion of FASD cases. As it was decided to exclude subjects with Fetal Alcohol Effect/Syndrome, those cases were identified, and excluded. This stage resulted in the exclusion of nine cases, four from the ADHD-severe and five from the ADHD-moderate groups.

Thus a total of 180 subjects remained relatively evenly distributed between the three study groups (60 subjects in the ADHD-severe, 58 in ADHD-moderate, and 62 in the clinic control) in the study.

Stage Three- Case Reviewed for Comorbidity

Stage Three of the group selection process involved the review of files in each of the twelve groups for any of four conditions that are often associated with children referred for assessment. The four conditions, other than ADHD were: learning disabilities, behavioural problems, psychiatric problems, and cognitive difficulties. This resulted in subjects in the study being identified as fitting into one of the following are the six possible categories:

a) Learning Disability: Reading Disorder (RD), Mathematics Disorder (MD), Non-verbal Learning Disability (NVLD), and Learning Disability unspecified (LD).

b) Behavioural: Conduct Disorder (CD), Oppositional Defiant Disorder (ODD), Fetal Alcohol Spectrum Disorder (FASD)

c) Psychiatric: Mood Disorders, Anxiety Disorder, Tourette's, Psychosis, Post Traumatic Stress Disorder.

d) Cognitive: Autism Spectrum Disorders and Mental Retardation (MR).

e) Multiple: two or more of 'a' through 'd'.

f) None: (none of 'a' through 'd')

As with selection for ADHD, determination of a comorbid disorder utilized a multi-evidence approach, using both qualitative and quantitative information contained in the subject's file. Evidence for each of the above comorbid disorders was based upon the following sources as indicated in table 3.6

Table 3.6

Evidence Sources for Determining Comorbid Disorders

Comorbid Condition	Evidence Source
Learning Problems/ Disorders	Previous diagnosis Placement in special education classes Existence of IPP; modified curriculum Extra assistance Repeated grades Below average achievement testing results (-2 SD or more below estimated cognitive ability)

	Conclusion from clinician
Behavioural/legal problems/concerns	Previous diagnoses (e.g., ODD; CD) or from current (SIDAC-R)
	Placement in special classes (Behavioural)
	Evidence of consequences (suspensions; actual charges; etc)
	Deviated scores on rating scales: BASC or BASC-2; any forms (Conduct Problems, Aggression)
	Documentation of significant problems due to conduct, aggression, Drug or alcohol use
	Conclusion from clinician
Emotional/ Psychiatric Problems	Previous diagnoses or from current (SIDAC-R)
	Previous counselling/therapy
	Prescribed psychotropic medications
	Experienced history of abuse
	Elevated profiles from rating scales such as BASC/BASC-2 on Depression; Anxiety; Somatization; Atypicality; or Withdrawal
	Elevation on any relevant rating scales (i.e. depression; anxiety)
	Conclusion from clinician
Cognitive/Developmental problems/concerns	Involvement of SLP/OT/Physiotherapy
	Previous diagnoses (MR; Autism; Asperger's)

	Previous intellectual assessments, excluding assessment for giftedness.
	Placement in special education classes
	Conclusion from clinician

All cases were reviewed for any of the above conditions independent of their ADHD status. Each case was then coded for the presence of each of the four conditions. In general, as the number of comorbid condition increases, there is an assumption that cognitive functioning would be negatively impacted. It was the intent to account for this during the data analysis stage, thus subjects were also coded for the degree of comorbidity, which is defined as the number of comorbid conditions present.

The degree of comorbidity is addressed through the use of a covariate analysis. Covariate variables are suspected to have had an impact on the study's dependent variables. However the study was not designed in such a manner that it could be controlled for in a more systematic manner (such as having subgroups based on the value of the covariate variable). In covariate analysis, variance due to the covariate variable can be separated/removed from the error variance statistically and thus it can help to clarify the relationship between the independent and dependent variables.

For ADHD research, the issue of comorbidity has been addressed in one of two ways: either by isolating those ADHD cases with no comorbid conditions or contrasting ADHD cases with specific comorbid conditions. In this study, a combined approach was taken. The exclusion of cases with comorbidity would have eliminated 76% of cases (137 cases of the 180 cases). Instead, cases were coded for the presence of the number of comorbid problems: none, one, two and three or more. This approach does obscure specific profiles for different types of comorbid problems by equating them based on the number of comorbid problems. It is possible, and likely, that a comorbid learning problem has a differential effect upon cognitive profiles than comorbid psychiatric or behavioural problems. However, it was believed that the alternative of classifying cases based on various combinations of comorbid problems would have resulted in subgroups with too few cases for any meaningful analysis.

Stage Four-ADHD Subtype Identification

The fourth and final stage in group selection involved identification of ADHD subtypes, for both the ADHD-severe and ADHD-moderate groups. This procedure involved examining individual's BASC, BASC-2 or Conners scores and comparing their relative scores for hyperactivity and inattention. If the scores both fell in the same range (i.e. both in the "clinically significant" range ($\geq$70) or "at-risk" range (60-69), they would be considered ADHD-combined. Individuals with one BASC/Conners symptom score in a higher range that the other, would be considered ADHD-hyperactive or ADHD-inattentive, dependent upon the higher score.

For example, an individual with an Attention score of 73, and Hyperactivity score of 65 would be placed in the ADHD-inattentive group. Conversely, an individual with an Attention score of 59, and Hyperactive score of 68 would be considered ADHD-hyperactive. An individual with an Attention score of 69 and Hyperactive score of 60 would be considered ADHD-combined. ADHD subtype classification was considered independently of whether the individual was placed in ADHD-severe or ADHD-moderate BASC groups.

In those cases where there was a previous ADHD subtype diagnosis, this method resulted in the same subtype classification.

Statistical Analyses

Group Differences Analysis

All analyses in this study follow the same stages. There is an initial comparison of the two ADHD study groups (severe, moderate) and the clinic control. This level will be denoted as ADHD-collapsed as the ADHD subtypes are not differentiated. This was followed by a post hoc analysis of group differences (Scheffe). These analysis addressed Hypotheses 1.1.1 to 1.1.5 and 2.1.1. to 2.1.4. The analysis of ADHD-subtypes consists of dividing the ADHD sample into ADHD-combined, ADHD-inattentive, and ADHD-hyperactive within the respective ADHD-severe and ADHD-moderate groups. The comparison at the subtype level consists of group differences between the ADHD-combined and the clinic control; ADHD-inattentive and the clinic control; and ADHD-hyperactive and the clinic control. This was followed by the post hoc analysis of group differences. These analyses addressed Hypotheses 1.2.1 to 1.4.5, and 2.2.1 to 2.4.4.

It should be noted that the same sample of clinic control subjects are used for all the four sets of analysis. The decision not to match cases was made due to the risk of reducing the sample size in the control group. It was felt that the advantage of maintaining power with a larger sample size outweighed the advantage provided through reduction of variance through matching.

Furthermore, there could have been a number of hypothesized factors upon which to match such as age, gender, cultural background, IQ level, and comorbidity. It was felt that the literature did not provide a consistent rational or list of variables upon which to match.

The rationale for conducting three separate analyses was made due to the interest in the cognitive profile of each of the three subtypes, with the differentiation between severe and moderate symptoms of ADHD (i.e., ADHD-severe and ADHD-moderate groups respectively), in comparison to the clinic control group. If it had been to compare the three subtypes against each other, a 4-group analysis of ADHD-combined, ADHD-inattentive, ADHD-hyperactive, and clinic control groups would have been used. However this latter type of analysis would not have accommodated the differentiation between ADHD symptom severities.

In terms of types of analyses, two sets of MANOVAs were used, for the Factor and subtest level scores. The first set included the 5 Factor scores; the second set included the 4 subtest scores.

Intra-individual Approach

The intra-individual approach consisted of a number of analysis intended to examine the relative strengths and weaknesses within an individual's profile on the SB-5. Within this approach, two different sets of analyses were completed, examination of group difference and cross tabulation.

ANOVA analysis of difference scores. A series of analysis based on the relative strengths and weakness of each of the Factor Scores were conducted. For each factor, that factor's difference score was defined as the difference of that factor score from the average of the five factor scores. More specifically, a positive difference score for WM would indicate a relative weakness of the WM score in comparison to the averaged Factor Score. A negative difference score would indicate a relative strength of the WM score in comparison to the averaged Factor Score. A series of one-way ANOVAs (and post hoc analyses) were used to examine group differences on these difference scores. These analyses addressed Hypotheses 3.1.1 to 3.4.2.

This difference score analysis was repeated at the subtest level, for two of the Factor Scores: WM and QR. The difference score is domain specific: verbal or nonverbal. Thus, a VWM difference score is defined as the difference between the VWM subtest score and the average of the five verbal subtest scores. A NVWM difference score is defined as the difference between the NVWM subtest score and the average of the five nonverbal subtest scores. As above, a series of ANOVAs (and post hoc analyses) was then completed on these difference scores. These analyses addressed Hypotheses 4.1.1 to 4.4.4.

Chi-square analysis. These analyses examined the number of cases in the following categories: relative strength, relative weakness, and no difference based upon cut-off values. They addressed Hypotheses 5.1.1 to 6.4.4.

Roid (2003c) provided a set of cut-off values for the SB-5 measures based upon two methods of determining the significant difference for a particular score in comparison to its respective Factor or domain-specific subtest score.

The first method is based upon the standard practice of declaring a difference between 2 scores as significant as developed by Davis (1959). This calculation involves the standard error of measurements for the particular score within the Factor or subtest scores and that of the averaged score. It is influenced by the number of scores within the respective cluster. For this study, this method will be called the Minimum Significant Difference (MSD).

The second method involves examining how common the difference between a specific Factor or domain-specific subtest score is in comparison to their respective Factor or domain-specific subtest scores based upon the SB-5 standardization sample. Roid suggested a value of 15% be used (i.e., a cut off value where such a difference score occurs in 15% of the standardization sample). These values are available at the Factor Score level but not at the domain-specific level, the closest values were those at the 10% level. In the interest of consistency, it was decided to use the same value for the Factor score and domain specific scores analysis, thus the 10% values were used. Table 3.7 provides the cut-off values based upon the above approaches. This approach was recommendations by Roid (2005), and for this study, it will be referred to as Roid's Minimum Significant Difference score (RMSD).

Table 3.7

Critical Values for the five factor scores and four subtest scores of interest.

SB-5 Measures	RMSD 10%	RMSD 15%	MSD
WM	12.8	11.0	9.2
QR	11.0	9.6	9.5
NVWM	3.2	not available	2.51
VWM	3.1	not available	2.76
NVQR	3.0	not available	2.63
VQR	3.1	not available	2.53

As indicated in the above table, the MSD approach provides the most liberal cut-off value (i.e., the smallest difference score to be considered significant). For Roid's approach (RMSD) the 10% value is more conservative than his 15% value. Two sets of Chi-square analyses were completed based upon either the MSD or RMSD cut off values.

Power Analysis

A series of power analysis will be carried out on the MANOVA and ANOVA data. The power of a statistical test reflects the likelihood of identifying an effect when there is one. The equation for calculating power is:

p = 1- 'beta'

with 'beta' representing the probability of making a Type II error. The generally accepted minimum value for acceptable power is 0.8 (Murphy & Myors, 2004).

For the Chi-square analysis, power value estimates were calculated only for significant results. This utilized a method as outlined by Portney & Watkins (2000).

CHAPTER FOUR: RESULTS

Study Group Characteristics

The average age of subjects selected for the final stage of this study was 11.5 years, ranging from just over 7 years to 17.9 years. The mean age differences between the three groups were not significant (*F*=1.62; *df*=2,177; *p*=.20; 11.6 years for ADHD-severe, 10.9 years for ADHD-moderate, and 11.8 years for clinic controls). The final study group as a whole showed an over representation of males (n=109; 60.6%), although this difference was not significant among the three groups (*Chi-square*=0.07; *df*=2). An accurate ethnic breakdown of the sample was not available as a full 50% of reports did not indicate this information. However, of cases identified, Caucasians made up the largest single group.

The majority of referrals for testing came from parents (68.9%; n=124), with school personal being the second most frequent source (23.9%, n=43). Previous cognitive testing was not completed on 56.1% (n=101) of the sample. The WISC (WISC-III or WISC-IV) was the most common cognitive test used (22.8%; n=41). The majority of the sample had no previous developmental diagnoses indicated on the report (64.4%; n=116). Learning disabilities accounted for the most frequently cited developmental disorder, accounting for approximately 20% (n=36) of cases. A substantial number of the reports did not provide specific details regarding the types of LD. However, 6.7% (n=12) of the samples were specifically identified with a Reading Disorder, while only one subject was identified with a Math Disorder. Language developmental difficulties were previously identified in 2.4% (n=4) of the sample. Lastly 32.2% (n=58) of the sample was identified as having been on an educational Individualized Program Plan (IPP).

A majority of the sample (66.7 %; n=120) did not have any previous psychiatric diagnosis, and 9.4% (n=17) was diagnosed with more than one psychiatric condition (not including ADHD). A breakdown of psychiatric conditions is indicated in Table 4.1.

Table 4.1

Percentages of final sample with various psychiatric diagnoses

Psychiatric Diagnosis	First Diagnosis	Second Diagnosis
None	66.7	81.7
Missing information	8.3	8.9
Anxiety Disorder	6.1	2.2
Oppositional Defiance	5.6	0.6
Mood Disorder	4.4	4.4
Other disorders	3.3	1.7
Tourette's	1.7	0
Conduct Disorder	1.1	0
Sleep Disorder	1.1	0
Obsessive Compulsive	1.1	0.6
Autism Spectrum	0.6	0

Background/historical information was collated into four areas: family, medical, educational, and social/legal histories. Information within these four groups included both that of the individual subject, and their extended family.

Information collected under the family history heading included whether or not the individual was adopted, any familial history of psychiatric disorders, ADHD, other significant medical problems, and educational difficulties. Medical history for each subject included information related to complications at birth, any diagnosis of developmental disorders, psychiatric diagnosis (up to two conditions were coded), medications related to ADHD, other psychotropic medications, and medications for physical problems. Educational history included information relating to repeated grades, additional educational support (i.e., resource room, behavioural support, teacher assistant, and tutors), and other services (i.e., Speech and Language, Occupational Therapy). Social/legal issues included involvement with Social Services, legal involvement (school suspensions/expulsions, legal charges/convictions), history of abuse (physical, sexual, neglect), and substance abuse history.

A series of Chi-square analysis was completed on each of the above information to identify any group differences. Table 4.2 presents the distribution of cases for each of the components in the family history area.

Table 4.2

Distribution of number of cases for each family history area

Areas	ADHD-severe	ADHD-moderate	Clinic Control	Total
Both parents	22 (36.7%)	36 (63.2%)	40 (64.5%)	98 (54.7%)
Adopted	3 (5.3%)	3 (5.7%)	2 (3.5%)	8 (4.8%)
Psychiatric	30 (57.7%)	25 (51.0%)	14 (27.5%)	69 (45.4%)
ADHD	11 (21.2%)	8 (17.0%)	1 (2.0%)	20 (13.3%)
Medical	2 (3.6%)	3 (6.5%)	11 (21.2%)	16 (10.5%)
Educational	31 (55.4%)	23 (47.9%)	13 (26.0%)	67 (43.5%)

There was a significant difference among the three groups on home situation (*Chi-square*=.001, *df*=6), with the ADHD-severe group having the lowest rate of children living with both parents.

The number of subjects who were adopted was not significantly different among the three groups (*Chi-square* = .85, *df*=2). Both the ADHD-severe and ADHD-moderate groups showed higher rates of familial histories of psychiatric diagnosis compared to clinic controls (*Chi-square*=.01, *df*=2).

There were significantly higher rates of familial psychiatric diagnosis for ADHD-severe and ADHD-moderate compared to the clinic controls (*Chi-square*=.01, *df*=2). Not surprisingly, subjects in both ADHD groups showed significantly higher rates of familial history of ADHD, compared to the clinic controls (*Chi-square*=0.01, *df*=2).

Analysis of the rate of familial medical problems was also significant; however, it is with the clinic control group. The clinic control group had a high rate of medical problems in at least one parent, compared to either ADHD groups (*Chi-square*=.03, *df*=10).

There was no significant difference among the three groups in regards to familial history of education difficulties (*Chi-square*=.19, *df*=12).

Table 4.3 illustrates the number and percentages of the rate of occurrences of various notable medical issues in subjects by study group.

Table 4.3

Subject Medical History

Areas	ADHD-severe	ADHD-moderate	Clinic Control	Total
Birth complications	14 (24.6%)	20 (40.0%)	4 (7.4%)	38 (23.6%)
Developmental disorder	16 (29.6%)	20 (37.0%)	12 (21.4%)	48 (29.3%)
Psychiatric disorder (first)	24 (44.4%)	15 (26.8%)	6 (10.9%)	45 (27.3%)
Psychiatric disorder (second)	9 (16.7%)	7 (12.7%)	1 (1.8%)	17 (10.4%)
ADHD medication	22 (36.7%)	23 (39.7%)	0 (0.0%)	45 (25.0%)
Psychiatric medication	12 (20.0%)	12 (20.7%)	2 (3.2%)	26 (14.4%)
Physical medication	4 (6.8%)	3 (5.5%)	5 (8.5%)	12 (6.9%)

The rate of birth complications reported for subjects was significantly higher in the ADHD-moderate group and to a lesser extent the ADHD-severe, compared to the clinic controls (*Chi-square*< .0004, *df*=2). There were no significant differences found between the number of developmental disorders found between the three groups (*Chi-square*=.20, *df*=2). However the number of cases with at least one previous co-morbid psychiatric disorder was found to be significantly higher in the ADHD-severe, ADHD-moderate compared to the clinic controls (*Chi-square*<.0004, *df*=2). This was also the case with the numbers of secondary psychiatric diagnosis's with the two ADHD groups having higher rates than the clinic controls (*Chi-square*=.03, *df*=2).

Information on medication use was inconsistently reported. The study collected information, where available, on medication types, classifying them into one of three groups, physical medication (such as for asthma), ADHD related (typically stimulants), or other psychotropic (antidepressants or antipsychotic). Twenty-five percent of the sample had been prescribed medication for ADHD (n=45). In addition to this, 11% (n=21) were prescribed antidepressants. There were a total of eleven individuals (6.1%) in the study prescribed antipsychotic. It is important to note that some individuals were prescribed more than one type of medication.

Not surprisingly, there was a significant difference found among the three groups in terms of ADHD medication use, this being driven primarily by the lack of ADHD related medication in the clinic control group (*Chi-square* < .0004, *df*=4). There was a significant difference for the use of other psychotropic medication among the three groups, with the two ADHD groups showing a high rate of use (*Chi-square* = .04, *df*=4). There was no difference in the use of medication for medical conditions (*Chi-square*=.82, *df*=2).

Table 4.4 indicates absolute numbers and percentages for occurrence of noted educational characteristics by study group.

Tables 4.4

Educational History

Areas	ADHD-severe	ADHD-moderate	Clinic Control	Total
Repeat grade	4 (6.7%)	7 (12.1%)	8 (12.9%)	19 (10.6%)
IPP	18 (30.0%)	23 (39.7%)	17 (27.4%)	58 (32.2%)
Extra help	23 (44.2%)	30 (56.6%)	25 (44.6%)	78 (48.4%)
Other services	30 (53.6%)	29 (56.9%)	14 (26.4%)	73 (45.6%)

Occurrence of repeated grades among the three groups was not significant; however the ADHD-severe group showed a lower overall incident compared to the ADHD-moderate and clinic controls (*Chi-square*=.48, *df*=2). There was no significant finding among the three groups in terms of being placed on an IPP (*Chi-square*=.32, *df*=2). There was no significant difference between the three groups in terms of extra educational programming (*Chi-square*=.35, *df*=2). All groups showed over 40% of subjects having received extra educational service. However, both ADHD groups received significantly high rates of other support services, compared to the clinic control group (*Chi-square*=.003, *df*=2).

Table 4.5 illustrates the absolute numbers and relative percentages of various social service and legal issues by study group.

Tables 4.5

Social and Legal Issues

Areas	ADHD-severe	ADHD-moderate	Clinic Control	Total
Social Services	3 (5.3%)	7 (13.0%)	2 (3.4%)	12 (7.1%)
Legal	11 (19.3%)	5 (9.6%)	2 (3.6%)	18 (11.0%)
Abuse	8 (14.5%)	2 (3.8%)	3 (5.6%)	13 (8.1%)
Substance	3 (5.5%)	3 (5.8%)	2 (3.7%)	8 (5.0%)

There was no significant difference among the three groups in terms of accessing Social Services (*Chi-square*=.09, *df*=4). The ADHD-severe group showed significant elevations in the area of legal difficulties compared to the ADHD-moderate and clinic control (*Chi-square*=.03, *df*=2).

In terms of abuse history, the ADHD-severe group showed a higher rate than the other two groups; however, this difference was not found to be significant (*Chi-square*=.09, *df*=2). Substance use among the three groups was also not significantly different (*Chi-square*=.48, *df*=6).

Comorbidity

As outlined in chapter three, each file was reviewed for the existence of the following comorbid problems: Learning problems, Behavioural problems, Psychiatric problems, and Cognitive problems.

Table 4.6 illustrates the distribution of comorbid conditions by the study groups. Tables 4.7 to 4.9 illustrate the distribution of comorbid conditions by ADHD subtypes.

Table 4.6

Number of Comorbid conditions by type, ADHD-collapsed and clinic control

Conditions	ADHD-severe	ADHD-moderate	Clinic Control	Total
None	5	12	28	43
LD	8	11	18	37
Behaviour	7	2	1	10
Psychiatric	11	8	4	23
Cognitive	3	3	1	7
Multiple	26	22	12	60
Total	60	58	62	180

Table 4.7

Number of Comorbid conditions by type, ADHD-combined

Conditions	ADHD-severe	ADHD-moderate	Total
None	1	3	4
LD	1	2	3
Behaviour	6	0	6
Psychiatric	5	5	10
Cognitive	1	0	1
Multiple	15	7	22
Total	29	17	46

Table 4.8

Number of Comorbid conditions by type, ADHD-inattentive

Conditions	ADHD-severe	ADHD-moderate	Total
None	3	9	12
LD	5	9	14
Behaviour	1	1	2
Psychiatric	6	3	9
Cognitive	0	3	3
Multiple	9	12	21
Total	24	37	61

Table 4.9

Number of Comorbid conditions by type, ADHD-hyperactive

Conditions	ADHD-severe	ADHD-moderate	Total
None	1	0	1
LD	2	0	2
Behaviour	0	1	1
Psychiatric	0	0	0
Cognitive	2	0	2
Multiple	2	3	5
Total	7	4	11

As can be seen from the tables above, the number of cases within each comorbid condition is very small. Therefore, instead of coding for specific conditions, it was decided to code for the number of comorbid conditions as a measure of complexity and severity.

From the main study group (n=180 cases), the breakdown of number of comorbid conditions is presented in Table 4.10.

Table 4.10

Number of comorbidity by study group

Groups	None	1 comorbid	2 comorbid	3 comorbid	4 comorbid	Total
Clinic Control	26	24	12	0	0	62
ADHD-severe	5	29	18	7	1	60
ADHD-moderate	12	24	14	6	2	58
Total	43	77	44	13	3	180

Post hoc it was decided to collapse the three and four comorbid numbers together, resulting in a coding for comorbidity as follows: '0' for no comorbid problems; '1' for 1 comorbid problem; '2' for 2 comorbid problems, and '3' for 3 or more comorbid problems.

An analysis of the number of comorbid conditions was run between the three groups. A Chi-square analysis was completed. There was a significant finding with 41.9% of the clinic control group having no comorbid conditions (n=26), whereas the ADHD-severe group had only 8.3% (n=5) with no comorbid condition, and 20.7% (n=12) of the ADHD-moderate (*Chi-square*<.0004, *df*=6). In addition, both the ADHD groups had higher numbers of cases with three or more comorbid disorders (13.3%, n=8 and 13.8%, n=8), while the control group had no cases.

Overall Cognitive Abilities

An ANOVA was completed on the Full Scale IQ of the three study groups. There was a significant difference found between the ADHD-moderate (95.7) and clinic control group (101.7). A MANOVA was completed for VIQ and NVIQ for the three study groups. Again there was a significant finding of comparative weakness on NVIQ, for the ADHD-moderate group (94.4) compared to the clinic control (101.8).

BASC/BASC-2 Characteristics

A series of one-way ANOVAs was conducted upon the various BASC or BASC-2 scores for the three study groups (ADHD-severe, ADHD-moderate, and the clinic control). BASC/BASC-2 scales included in the analysis were the four summary scores (i.e., Externalizing Problems, Internalizing Problems, Adaptive Skills Scale and the BSI). As well the two subscale scores, Hyperactivity and Attention Problems were also analyzed. Table 4.11 presents results for the BASC/BASC-2 Parent Rating Scale scores, while table 4.12 presents the results for the Teacher Rating Scale.

Table 4.11

ANOVA and Post hoc (Scheffe) analysis summary of BASC/BASC-2 Parent Rating Scale scores for each ADHD subtypes.

BASC scales	Combined	Inattentive	Hyperactive	Collapsed
Externalizing	sev>cc	sev>cc	sev>cc	sev >cc
	mod>cc	sev>mod	mod>cc	mod>cc
	sev>mod			sev>mod
Internalizing	sev>cc	Sev>cc	ns	sev>cc
	sev>mod			sev>mod
Adaptive	cc>sev	cc>sev	ns	cc>sev
	cc>mod	cc>mod		cc>mod
BSI	sev>cc	sev>cc	sev>cc	sev>cc
	mod>cc	mod>cc	mod>cc	mod>cc
	sev>mod	sev>mod		sev>mod
Hyperactive	sev>cc	sev>cc	sev>cc	sev>cc
	mod>cc	mod>cc	mod>cc	mod>cc
	sev>mod	sev>mod	sev>mod	sev>mod
Attention	sev>cc	sev>cc	sev>cc	sev>cc
	mod>cc	mod>cc		mod>cc
	sev>mod	sev>mod		sev>mod

sev=ADHD-severe
mod=ADHD-moderate
cc= clinic control
ns=not significant

BASC/BASC-2 PRS Results

Results of ANOVA analysis conducted upon the PRS indicated significant differences between all ADHD subjects collapsed together and each of the ADHD subtype groups and clinic control on all scales examined. BSI score differences were found for ADHD-collapsed, as well as all ADHD subtypes. With all ADHD groups, there was a significant difference found between all study groups with each other (ADHD-severe vs. clinic control, ADHD-moderate vs. clinic control, and ADHD-severe vs. ADHD-moderate). However for the ADHD-hyperactive subtype, there was no significant difference found between the severe and moderate subjects. Overall, the ADHD-severe groups (within each ADHD subtype group) had BSI score close to 3 standard deviations above average, or well above the "clinically significant" range. This was followed by the ADHD-moderate symptom groups, who's scores ranged from two standard deviations above average (62.3) or within the "At-risk" range, to within average range (55.7).

For the Hyperactivity scale there was a significant difference found between all study groups with each other (ADHD-severe vs. clinic control, ADHD-moderate vs. clinic control, and ADHD-severe vs. ADHD-moderate). The ADHD-severe group scores were consistently higher than either the moderate symptom group or the clinic control, typically close to three standard deviations above average.

For the Attention scale, the same pattern emerged with the exception in the ADHD-hyperactive subtype, who only demonstrated a significant difference between the ADHD-severe and clinic control.

The ADHD-severe group were the rated as the most severely impacted by the parents overall. They have the highest rating for symptoms (Hyperactive, Attention Problems, Internalizing and Externalizing), and lowest rating for Adaptive skills, of the three symptom groups (ADHD-severe, ADHD-moderate and clinic control). For most of the ANOVA's, the ADHD-moderate group tended to be one standard deviation above average, with the exception of the Internalizing scale, in which they were average for all ADHD subjects collapsed, as well as the three ADHD subtypes.

Table 4.12

ANOVA and Post hoc (Scheffe) analysis summary of BASC/BASC-2 Teacher Rating Scale scores for each ADHD subtypes.

BASC scales	Combined	Inattentive	Hyperactive	Collapsed
Externalizing	sev>cc	sev>cc	sev>cc	sev>cc
	mod>cc		mod>cc	mod>cc
Internalizing	ns	ns	ns	ns
Adaptive	cc>sev	cc>sev	Ns	cc>sev
BSI	sev>cc	sev>cc	sev>cc	sev>cc
	mod>cc	mod>cc	mod>cc	mod>cc
Hyperactive	sev>cc	sev>cc	sev>cc	sev>cc
	mod>cc	mod>cc	mod>cc	mod>cc
Attention	sev>cc	sev>cc	sev>cc	sev>cc
	mod>cc	mod>cc		mod>cc
		sev>mod		sev>mod

sev=ADHD-severe
mod=ADHD-moderate
cc= clinic control

ns=not significant

BASC/BASC-2 TRS Results

For the TRS, ANOVA results indicated that the BSI scores were significantly difference between the ADHD-severe group and clinic control, within all ADHD subtype groups as well as the ADHD-collapsed group. As well, The ADHD-moderate symptoms groups showed significantly higher BSI scores compared to the clinic control. Unlike the case with the PRS, there was no differentiation between the ADHD-moderate and severe groups. Interestingly, BSI scores for the two symptom levels both barely hit the "at-risk" range (60 to 69).

For the Hyperactive scale, the same pattern of significant difference was found. However, scores overall were lower, with only the ADHD-severe subjects within the ADHD-combined subtype, and ADHD-moderate, within the ADHD-hyperactive groups showing scores in the "At-risk" range.

For the Attention scale, a similar pattern was found with some notable differences. There was additional separation between the ADHD-moderate and severe groups within the ADHD-inattentive and ADHD-collapsed groups. As well, within the ADHD-hyperactive subtype, there was no separation between the moderate and clinic control groups. The Attention scale scores were also lower on the TRS compared to the PRS. Only the ADHD-severe and moderate groups within the ADHD-combined subtype, and the ADHD-severe within the collapsed and ADHD-inattention groups were elevated to "At-risk" levels.

Another notable difference between the PRS and TRS involved the Internalizing scale scores. There were no significant differences on this scale between any of the groups analyzed.

SB-5 Results

SB-5 results will be presented in the following sections. The first series of results presented will be from the MANOVA analysis of factor and subtest scores. This will be followed by results from the ANOVA analysis of factor and subtest difference scores. This section will conclude with results from the Chi-square analysis.

Group Mean Differences on SB-5 Factor Scores

Table 4.13 indicates the distributions of cases within each ADHD subtype.

Table 4.13

Number of subjects within each ADHD subtype group

Groups	Combined	Inattentive	Hyperactive	Collapsed
ADHD-severe	29	24	7	60
ADHD-moderate	17	37	4	58
Total	46	61	11	118

Hypotheses 1.1.1 to 1.4.5 addressed questions regarding differences among the three study groups on the SB-5 factor scores. Table 4.14 presents a summary of MANOVA conducted for these hypotheses. Refer to Appendix tables 1a to 1e for MANOVA analysis tables for factor scores.

Table 4.14

MANOVA and Post hoc (Scheffe) analysis summary of factor scores for each ADHD subtypes.

SB Factors	Combined	Inattentive	Hyperactive	Collapsed
FR	ns	ns	ns	ns
KN	ns	ns	ns	ns
QR	ns	ns	ns	ns
VS	ns	ns	ns	ns
WM	cc>mod	*cc>mod	ns	*cc>mod *sev>mod

*supported by main effect MANOVA
ns=not significant
cc=clinic control
mod=ADHD-moderate
sev=ADHD-severe

ADHD-collapsed

Hypotheses 1.1.1 to 1.1.5 stated that there would be no difference among the average factor scores of the three study groups (ADHD-severe, ADHD-moderate, and clinic control) when the ADHD subjects were not divided into subtypes (ADHD-collapsed). For these hypotheses, only Hypothesis 1.1.1 (dealing with WM) was rejected. More specifically, the WM factor score of the ADHD moderate groups was significantly weaker than the other two groups. However, Hypotheses 1.1.2 (dealing with FR), 1.1.3 (dealing with KN), 1.1.4 (dealing with QR), and 1.1.5 (dealing with VS) were not rejected. These results remained the same when the number of comorbid conditions was controlled for, using a series of MANCOVA analysis.

Results of the power analysis (see appendix) for Hypothesis 1.1.1 to 1.1.5 indicated adequate power at .93 was found for Hypothesis 1.1.1, dealing with WM only. Power values for the MANCOVA analysis also indicate adequate power for the WM hypothesis (.89). In addition the power value for Hypothesis 1.1.4 (QR) also approaches the adequate level (.75).

ADHD-combined

Hypotheses 1.2.1 to 1.2.5 stated that there would be no difference among the average factor scores of the three study groups (ADHD-severe, ADHD-moderate, and clinic control) for ADHD-combined subtype. For these hypotheses, only Hypothesis 1.2.1 (dealing with WM) was rejected. The WM factor score for the ADHD-moderate group was found to be significantly weaker than that of the clinic control group. However, this was not supported by a main effect. Hypotheses 1.2.2 (dealing with FR), 1.2.3 (dealing with KN), 1.2.4 (dealing with QR) and 1.2.5 (dealing with VS) were not rejected. These results remained the same when the number of comorbid conditions was controlled for, using a series of MANCOVA analysis.

Results of the power analysis for Hypothesis 1.2.1 to 1.2.5 did not find any values at .8 or higher. However, for Hypothesis 1.2.1 (WM) the power value was .63. Power values for the MANCOVA analysis did not indicate adequate power for any of the five hypotheses.

ADHD-inattentive

Hypotheses 1.3.1 to 1.3.5 stated that there would be no difference among the average factor scores of the three study groups (ADHD-severe, ADHD-moderate, and clinic control) for ADHD-inattentive subtype. For these hypotheses, only Hypothesis 1.3.1 (dealing with WM) was rejected. The WM factor score for the ADHD-moderate group was found to be significantly weaker than that of the clinic control group. Hypotheses 1.3.2 (dealing with FR), 1.3.3 (dealing with KN), 1.3.4 (dealing with QR) and 1.3.5 (dealing with VS) were not rejected. These results remained the same when the number of comorbid conditions was controlled for, using a series of MANCOVA analysis.

Results of the power analysis for Hypothesis 1.3.1 to 1.3.5 did not find any values at .8 or higher. However, for hypothesis 1.3.1 (WM) the power value was .77. Power values for the MANCOVA analysis indicate adequate power for the QR factor hypothesis (.86). In addition the power value for hypothesis 1.3.1 (WM) also approaches the adequate level (.71).

ADHD-hyperactive

Hypotheses 1.4.1 to 1.4.5 stated that there would be no difference among the average factor scores of the three study groups (ADHD-severe, ADHD-moderate, and clinic control) for ADHD-hyperactive subtype. All five hypotheses were not rejected. These results remained the same when the number of comorbid conditions was controlled for, using a series of MANCOVA analysis.

Results of the power analysis for Hypothesis 1.4.1 to 1.4.5 did not find any values at .8 or higher. This remained true for the MANCOVA power calculations, although the value for Hypothesis 1.4.2 (FR) was close (.74), as was Hypothesis 1.4.3 (KN), which was .71.

Group Mean Differences on SB-5 Subtest Scores

Hypotheses 2.1.1 to 2.4.4 addressed questions regarding differences among the three study groups on the SB-5 subtest scores. Table 4.15 presents a summary of MANOVA conducted for these hypotheses. Refer to Appendix tables 2a to 2e for MANOVA analysis tables for subtest scores.

Table 4.15

MANOVA and Post hoc (Scheffe) analysis summary of subtest scores for each ADHD subtypes.

SB Subtests	Combined	Inattentive	Hyperactive	Collapsed
NVQR	ns	ns	ns	ns
NVWM	cc>mod	*cc>mod	ns	cc>mod
VQR	ns	*cc>sev	ns	cc>sev cc>mod
VWM	ns	ns	ns	sev>mod

*supported by main effect MANOVA ns=not significant
cc=clinic control
mod=ADHD-moderate
sev=ADHD-severe

ADHD-collapsed

Hypotheses 2.1.1 to 2.1.4 stated that there would be no difference among the average subtest scores of the three study groups (ADHD-severe, ADHD-moderate, and clinic control) when the ADHD subjects were not divided into subtypes (ADHD-collapsed). For these hypotheses, Hypotheses 2.1.1 (dealing with NVWM), Hypothesis 2.1.3 (dealing with VWM), and Hypothesis 2.1.4 (dealing with VQR) were all rejected. More specifically, the ADHD-moderate group had a significantly weaker NVWM and VQR scores than the clinic control group. In addition, the ADHD-severe group also had a significantly weaker VQR score than the clinic control. Lastly, the ADHD-moderate group has a significantly weaker VWM score than the ADHD-severe. However, none of the above findings were supported by a main effect.

When the number of comorbid conditions was controlled for (MANCOVA analysis), ADHD-moderate group continued to have a weaker NVWM score than the clinic control, only now this was supported by a main effect. For the VQR finding, the ADHD-severe was no longer found to be significantly weaker than the clinic control. However, the VWM finding was now supported by a main effect.

Results of the power analysis for Hypothesis 2.1.1 to 2.1.4 found only one value that was above the adequate value, at .92, for Hypothesis 2.1.1 (NVWM). In addition, the power value for the Hypothesis 2.1.4 (VQR) was close to adequate (.75). A similar pattern was found for the MANCOVA power calculations, with values of .88 and .79, for NVWM and VQR respectively.

ADHD-combined

Hypotheses 2.2.1 to 2.2.4 stated that there would be no difference among the average subtest scores of the three study groups (ADHD-severe, ADHD-moderate, and clinic control) for ADHD-combined subtype. For these hypotheses, only Hypothesis 2.2.1 (dealing with NVWM) was rejected. More specifically, the ADHD-moderate group had a significantly weaker NVWM score than the clinic control group. However this was not supported by a main effect.

When results were controlled for number of comorbid conditions (MANCOVA analysis) there were some changes in the results. For NVWM, the ADHD-severe group was also found to be significantly weaker than the clinic control group. In addition, both of the ADHD group differences were supported by a main effect. Controlling for number of comorbid conditions also resulted in a significant finding for VWM (Hypothesis 2.2.3). Interestingly, the ADHD-severe group had a significantly stronger score than both the ADHD-moderate and clinic control groups.

Results of the power analysis for Hypothesis 2.2.1 to 2.2.4 did not find any values at .8 or higher. This remained true for the MANCOVA power calculations. However, the power value for Hypothesis 2.2.3 (VWM) had adequate levels (.80).

ADHD-inattentive

Hypotheses 2.3.1 to 2.3.4 stated that there would be no difference among the average subtest scores of the three study groups (ADHD-severe, ADHD-moderate, and clinic control) for the ADHD-inattentive subtype. For these hypotheses, Hypotheses 2.3.1 (dealing with NVWM), and 2.3.4 (dealing with VQR) were both rejected. More specifically, the ADHD-moderate group had a significantly weaker NVWM score than the clinic control. For VQR, the ADHD-severe group had a significantly weaker score than the clinic control group. Both Hypotheses 2.3.2 and 2.3.3 were not rejected.

When results were controlled for number of comorbid conditions (MANCOVA analysis) there were no changes in these results.

Results of the power analysis for Hypothesis 2.3.1 to 2.3.4 found one value at .8 or higher, for Hypothesis 2.3.4 (VQR), which was .84. In addition, the power value for Hypothesis 2.3.1 (NVWM) approached adequate value (.74). The power analysis for the MANCOVA showed one adequate value, for Hypothesis 2.3.4 (VQR), which was at .91.

ADHD-hyperactive

Hypotheses 2.4.1 to 2.4.4 stated that there would be no difference among the average subtest scores of the three study groups (ADHD-severe, ADHD-moderate, and clinic control) for the ADHD-hyperactive subtype. All of these hypotheses were not rejected.

When results were controlled for number of comorbid conditions (MANCOVA analysis) there were no changes in these results.

Results of the power analysis for Hypothesis 2.4.1 to 2.4.4 did not find any values at .8 or higher. This remained true for the MANCOVA power calculations.

Intra-individual Analysis of SB-5 Factor and Subtest Scores

In order to test Hypothesis 3.1.1 to 4.4.4, a series of intra-individual analyses were completed. As indicated in chapter three, the intra-individual analysis consisted of a number of stages. The intent of this analysis was to look at the relative strengths and weaknesses within an individual's profile score on the SB-5.

To accomplish this, each factor score was compared to the average of all factor scores. At the subtest level, this analysis was only applied to the WM and QR subtests. Each subtest score was compared to the average of its' verbal or nonverbal subtest scores. From this a difference score was generated for each factor or subtest score, for each individual.

Each difference score could be either positive, indicating a relative weakness in that factor or subtest, or negative, indicating a relative strength. A difference score of zero would indicate no difference between that specific factor or subtest score compared to the average of all factor scores or the subtest's respective domain average.

Results from the initial ANOVA conducted upon the difference scores are indicated in table 4.16, uncorrected for number of comorbid conditions. A series of ANOVAs was completed on these difference scores for the selected Factors (WM and QR) and their four respective subtests. Refer to Appendix tables 3a to 3i for ANOVA analysis tables for factor difference scores, and tables 4a to 4q for subtest difference scores.

Factor Score Analysis

Hypotheses 3.1.1 to 3.4.2 addressed the difference scores for the two Factor score (WM, QR) analysis for each of the ADHD subtypes as well as all subtypes collapsed together (ADHD-collapsed). Figures 4.1 and 4.2 (appendix) illustrate the mean difference scores for WM and QR for the study groups by ADHD subtypes.

Table 4.16

Summary of ANOVA results for the difference scores of ADHD-severe, ADHD-moderate, and Clinic Control group, uncorrected for number of comorbid conditions.

Variable	Combined	Inattentive	Hyperactive	ADHD Collapsed
QR difference	ns	ns	ns	ns
WM difference	ns	cc<mod	ns	cc<mod
NVQR difference	ns	ns	ns	ns
NVWM difference	ns	ns	ns	cc<mod

VQR difference	ns	cc<sev	ns	cc<sev
VWM difference	ns	ns	ns	ns

cc=clinic control
mod=ADHD-moderate
sev=ADHD-severe

ns=not significant

ADHD-collapsed. Hypotheses 3.1.1 and 3.1.2 stated that there would be no difference in the average WM and QR difference scores (DWM and DQR respectively) among the three study groups (ADHD-severe, ADHD-moderate, and clinic control) when the ADHD subjects were not divided into subtypes (ADHD-collapsed). Only Hypothesis 3.1.1 was rejected. Specifically, the ADHD-moderate group had a significantly larger intra-individual WM weakness when compared to the clinic control.

When controlled for number of comorbid conditions, there were no changes in these results.

ADHD subtypes analysis. Hypotheses 3.2.1 to 3.4.2 stated that there would be no difference in the DWM and DQR scores among the three study groups (ADHD-severe, ADHD-moderate, and clinic control) within the three ADHD subtypes (ADHD-combined, ADHD-inattentive, ADHD-hyperactive). Only Hypothesis 3.3.1 was rejected. Specifically, for the ADHD-inattentive subtypes, the ADHD-moderate group had a significantly larger intra-individual WM weakness when compared to the clinic control.

When controlled for number of comorbid conditions, there were no changes in these results.

Subtest Score Analysis

Figures 4.3 to 4.6 (appendix) illustrate the difference scores for the respective subtests for the study groups with the ADHD subtypes.

ADHD-collapsed. Hypotheses 4.1.1 to 4.1.4 stated that there would be no difference in the average NVWM, NVQR, VWM, and NVQR difference scores (DNVWM, DNVQR, DVWM, and DVQR respectively) among the three study groups (ADHD-severe, ADHD-moderate, and clinic control) when the ADHD subjects were not divided into subtypes (ADHD-collapsed). Only Hypothesis 4.1.1 (dealing with DNVWM) and Hypothesis 4.1.4 (dealing with DVQR) were rejected. More specifically, the ADHD-moderate group has a significantly larger intra-individual weakness in NVWM when compared to the clinic control. As well, the ADHD-severe group had a significantly larger intra-individual weakness in VQR when compared to the clinic control.

When controlled for number of comorbid conditions, there were some changes in these results. For Hypothesis 4.1.1 (DNVWM), the ADHD-severe group also showed significant larger intra-individual weakness in NVWM compared to the clinic control. For Hypothesis 4.1.3 (DVWM), the ADHD-severe group showed a significantly larger intra-individual weakness compared to the ADHD-moderate group. However, this finding was not supported by a main effect.

ADHD subtypes analysis. Hypothesis 4.2.1 to 4.4.4 stated that there would be no difference in the average NVWM, NVQR, VWM, and NVQR difference scores (DNVWM, DNVQR, DVWM, and DVQR respectively) among the three study groups (ADHD-severe, ADHD-moderate, and clinic control) within the ADHD subtypes (ADHD-combined, ADHD-inattentive, ADHD-hyperactive). Only Hypothesis 4.3.4 (ADHD-inattentive subtype and DVQR) was rejected. Specifically, within the ADHD-inattentive subtype, the ADHD-severe group had a significantly larger intra-individual weakness in VQR when compared to the clinic control.

When controlled for number of comorbid conditions, there was one change in these results. In particular, for Hypothesis 4.2.1 (ADHD-combined type, DNVWM), the ADHD-severe and ADHD-moderate groups both showed a greater intra-individual weakness in nonverbal working memory compared to the clinic control group.

Chi-square Analysis

To address Hypotheses 5.1.1 to 6.4.4, a series of Chi-square analysis was completed. These hypotheses address the question of whether a greater number of subjects with the various ADHD subtypes have significant relative difference in their WM or QR factor, and respective subtest scores compared to subjects from the clinic control group.

Chi-square Analysis for Factor Scores

Tables 4.17 to 4.18 presents the summary of Chi-square analyses based upon either the MSD or RMSD cut-off values for the SB-5 factor scores (WM and QR).

Tables 4.17

Significance Values for Chi-square Analysis of Factor Scores for ADHD subtypes based on MSD critical values

Variables	Combined	Inattentive	Hyperactive	Collapsed
WM count (9.2)*	0.87	0.33	0.58	0.31
QR count (9.5)*	0.39	0.32	0.30	0.13

*critical value is based on the difference score that is found to be significant at the 0.05 level based upon calculations as per Davis (1959). Critical values for the Factor scores are from Roid (2005).

Table 4.18

Significance Values for Chi Square Analysis of factor Scores for ADHD subtypes based on RMSD - 10% critical values

Variables	Combined	Inattentive	Hyperactive	Collapsed
WM count (12.8)*	0.98	0.84	0.84	0.95
QR count (11.0)*	0.17	0.34	0.81	0.23

*critical value is based on the difference score that is found in 10% of the standardization sample. The calculation of subtest score difference is based upon means generated within each of the Verbal and Nonverbal domains (see table B-3, Roid, 2003a).

ADHD-collapsed. Hypothesis 5.1.1 and 5.1.2 addressed the number of subjects with relative intra-individual difference in the two Factor scores (WM, QR), for the three study groups (ADHD-severe, ADHD-moderate, and clinic control) when the ADHD subtypes are collapsed (ADHD-collapsed). Both hypotheses were not rejected using critical values generated by either MSD or RMSD values.

ADHD-combined. Hypothesis 5.2.1 and 5.2.2 addressed the number of subjects with relative intra-individual difference in the two Factor scores (WM, QR), for the three study groups (ADHD-severe, ADHD-moderate, and clinic control) for the ADHD-combined subtype. Both hypotheses were not rejected using critical values generated by either MSD or RMSD values.

ADHD-inattentive. Hypothesis 5.3.1 and 5.3.2 addressed the number of subjects with relative intra-individual difference in the two Factor scores (WM, QR), for the three study groups (ADHD-severe, ADHD-moderate, and clinic control) for ADHD-inattentive subtype. Both hypotheses were not rejected using critical values generated by either MSD or RMSD values.

ADHD-hyperactive. Hypothesis 5.4.1 and 5.4.2 addressed the number of subjects with relative intra-individual difference in the two Factor scores (WM, QR), for the three study groups (ADHD-severe, ADHD-moderate, and clinic control) for ADHD-hyperactive subtype. Both hypotheses were not rejected using critical values generated by either MSD or RMSD values.

Chi-square Analysis for Subtest Scores

Tables 4.19 and 4.20 presents the summary of Chi-square analyses based on either the MSD or RMSD cut-off values for the subtest scores (NVWM, VWM, NVQR, and VQR).

Table 4.19

Significance Values for Chi Square Analysis of Subtest Scores for ADHD subtypes based on MSD critical values

Variables	Combined	Inattentive	Hyperactive	Collapsed
NVWM count (2.51)*	0.02	0.20	0.71	0.11
VWM count (2.76)*	0.48	0.88	0.06	0.44
NVQR count (2.63)*	0.15	0.25	0.20	0.06
VQR count (2.53)*	0.38	0.05	0.50	0.05

* critical value is based on the difference score that is found to be significant at the 0.05 level based upon calculations as per Davis (1959). Critical values for subtest scores are from Roid, 2003a)

Table 4.20

Significance Values for Chi Square Analysis of Subtest Score for ADHD subtypes based on RMSD - 10% critical values

Variables	Combined	Inattentive	Hyperactive	Collapsed
NVWM count (3.2)*	0.67	0.38	0.55	0.62
VWM count (3.1)*	0.55	0.64	0.80	0.32
NVQR count (3.0)*	0.23	0.64	0.20	0.21
VQR count (3.1)*	0.43	0.004	0.77	0.01

*critical value is based on the difference score that is found in 10% of the standardization sample. The calculation of subtest score difference is based upon means generated within each of the Verbal and Nonverbal domains (see table B-3, Roid, 2003a).

ADHD-collapsed. Hypothesis 6.1.1 and 6.1.4 addressed the number of subjects with relative intra-individual difference in the four subtest scores (NVWM, NVQR, VWM, and VQR), for the three study groups (ADHD-severe, ADHD-moderate, and clinic control) when the ADHD subtypes are collapsed

(ADHD-collapsed). Only Hypothesis 6.1.4 (dealing with VQR) was rejected based on either MSD or RMSD values. A power calculation was conducted for this analysis, indicating an estimated value at .55.

In examining the result based upon the MSD critical values, the significant finding was due to the clinic control having eight individuals (12.9%) with a relative strength in VQR, while none of the ADHD-severe group, and only three (5.2%) of the ADHD-moderate having a corresponding strength.

In examining the result based upon the RMSD critical values, the significant finding was due to the clinic control having six individuals (9.7%) with a relative strength in VQR, while none of the ADHD-severe group, and only one (1.7%) of the ADHD-moderate having a corresponding strength. In addition, the number of cases with a relative weakness was also significantly different. The clinic control group had only three cases (4.8%) while ADHD-severe had ten cases (16.7%) and the ADHD-moderate had five cases (8.6%).

ADHD-combined. Hypothesis 6.2.1 and 6.2.4 addressed the number of subjects with relative intra-individual difference in the four subtest scores (NVWM, NVQR, VWM, and VQR), for the three study groups (ADHD-severe, ADHD-moderate, and clinic control) for ADHD-combined subtype. Only Hypothesis 6.2.1 (dealing with NVWM) was rejected based on the MSD value, but not using RMSD. A power calculation for this result was conducted, resulting in an estimated value of .66.

In examining the results, the significant finding was due to a relatively small number of subjects in the clinic control group having a relative weakness in

NVWM (14.5%), while both the ADHD-severe and ADHD-moderate groups had a significantly higher number of cases (41.4% and 47.1% respectively).

ADHD-inattentive. Hypothesis 6.3.1 and 6.3.4 addressed the number of subjects with relative intra-individual difference in the four subtest scores (NVWM, NVQR, VWM, and VQR), for the three study groups (ADHD-severe, ADHD-moderate, and clinic control) for the ADHD-inattentive subtype. Only Hypothesis 6.3.4 (dealing with VQR) was rejected based on either MSD or RMSD values. A power calculation conducted for this result indicated in an estimated power value of .75.

In examining the results based upon the MSD value, the significant finding was due to the ADHD-severe group having a higher number of individuals (29.2%) with a relative weakness in VQR than either the clinic control (11.3%) or ADHD-moderate (13.5%).

In examining the results based upon the RMSD value, the significant finding was also due to the ADHD-severe group having a higher number of individuals (29.2%) with a relative weakness in VQR than either the clinic control (4.8%) or ADHD-moderate (10.8%).

ADHD-hyperactive. Hypothesis 6.4.1 and 6.4.4 addressed the number of subjects with relative intra-individual difference in the four subtest scores (NVWM, NVQR, VWM, and VQR), for the three study groups (ADHD-severe, ADHD-moderate, and clinic control) for the ADHD-hyperactive subtype. All of the hypotheses were not rejected based on either MSD or RMSD values.

Summary of Results

A summary of the results will now be provided, as they pertain to the specific hypothesis outlined in chapter two.

Group Mean Differences

Table 4.21 presents a summary of the hypotheses statements related to group mean differences on the five Factor score and selected subtest scores.

Table 4.21

Summary Table of Hypothesis Statements for Group Difference Analysis.

Hypothesis number	Statement	Finding* (power value)
1.1.1 (ADHD-collapsed)	There will be no significant difference among the average WM score of the three study groups.	NC=Rejected (.93) C=Rejected (.89)
1.1.2 (ADHD-collapsed)	There will be no significant difference among the average FR score of the three study groups.	NC=not rejected (.35) C=not rejected (.55)
1.1.3 (ADHD-collapsed)	There will be no significant difference among the average KN score of the three study groups.	NC=not rejected (.27) C=not rejected (.51)
1.1.4 (ADHD-collapsed)	There will be no significant difference among the average QR score of the three study groups.	NC=not rejected (.59) C=not rejected (.75)

1.1.5 (ADHD-collapsed)	There will be no significant difference among the average VS score of the three study groups.	NC=not rejected (.41) C=not rejected (.59)
1.2.1 (ADHD-combined)	There will be no significant difference among the average WM score of the three study groups.	NC=Rejected (.63) C=Rejected (.58)
1.2.2 (ADHD-combined)	There will be no significant difference among the average FR score of the three study groups.	NC=not rejected (.10) C=not rejected (.43)
1.2.3 (ADHD-combined)	There will be no significant difference among the average KN score of the three study groups.	NC=not rejected (.29) C=not rejected (.65)
1.2.4 (ADHD-combined)	There will be no significant difference among the average QR score of the three study groups.	NC=not rejected (.25) C=not rejected (.33)
1.2.5 (ADHD-combined)	There will be no significant difference among the average VS score of the three study groups.	NC=not rejected (.35) C=not rejected (.53)
1.3.1 (ADHD-inattentive)	There will be no significant difference among the average WM score of the three study groups.	NC=Rejected (.77) C=Rejected (.71)
1.3.2 (ADHD-	There will be no significant difference among the average FR score of the	NC=not rejected (.26) C=not rejected (.39)

inattentive)	three study groups.	
1.3.3 (ADHD-inattentive)	There will be no significant difference among the average KN score of the three study groups.	NC=not rejected (.10) C=not rejected (.37)
1.3.4 (ADHD-inattentive)	There will be no significant difference among the average QR score of the three study groups.	NC=not rejected (.56) C=not rejected (.86)
1.3.5 (ADHD-inattentive)	There will be no significant difference among the average VS score of the three study groups.	NC=not rejected (.16) C=not rejected (.22)
1.4.1 (ADHD-hyperactive)	There will be no significant difference among the average WM score of the three study groups.	NC=not rejected (.19) C=not rejected (.19)
1.4.2 (ADHD-hyperactive)	There will be no significant difference among the average FR score of the three study groups.	NC=not rejected (.53) C=not rejected (.74)
1.4.3 (ADHD-hyperactive)	There will be no significant difference among the average KN score of the three study groups.	NC=not rejected (.08) C=not rejected (.71)
1.4.4 (ADHD-hyperactive)	There will be no significant difference among the average QR score of the three study groups.	NC=not rejected (.17) C=not rejected (.54)
1.4.5	There will be no significant difference	NC=not rejected (.12)

(ADHD-hyperactive)	among the average VS score of the three study groups.	C=not rejected (.32)
2.1.1 (ADHD-collapsed)	There will be no significant difference among the average NVWM score of the three study groups.	NC=Rejected (.92) C=Rejected (.88)
2.1.2 (ADHD-collapsed)	There will be no significant difference among the average NVQR score of the three study groups.	NC=not rejected (.19) C=not rejected (.39)
2.1.3 (ADHD-collapsed)	There will be no significant difference among the average VWM score of the three study groups.	NC=Rejected (.64) C=Rejected (.67)
2.1.4 (ADHD-collapsed)	There will be no significant difference among the average VQR score of the three study groups.	NC=Rejected (.75) C=Rejected (.79)
2.2.1 (ADHD-combined)	There will be no significant difference among the average NVWM score of the three study groups.	NC=Rejected (.71) C=Rejected (.69)
2.2.2 (ADHD-combined)	There will be no significant difference among the average NVQR score of the three study groups.	NC=not rejected (.17) C=not rejected (.19)
2.2.3 (ADHD-combined)	There will be no significant difference among the average VWM score of the three study groups.	NC=not rejected (.46) C=Rejected (.80)

2.2.4 (ADHD-combined)	There will be no significant difference among the average VQR score of the three study groups.	NC=not rejected (.26) C=not rejected (.33)
2.3.1 (ADHD-inattentive)	There will be no significant difference among the average NVWM score of the three study groups.	NC=Rejected (.74) C=Rejected (.67)
2.3.2 (ADHD-inattentive)	There will be no significant difference among the average NVQR score of the three study groups.	NC=not rejected (.16) C=not rejected (.61)
2.3.3 (ADHD-inattentive)	There will be no significant difference among the average VWM score of the three study groups.	NC=not rejected (.35) C=Rejected (.32)
2.3.4 (ADHD-inattentive)	There will be no significant difference among the average VQR score of the three study groups.	NC=Rejected (.84) C=Rejected (.91)
2.4.1 (ADHD-hyperactive)	There will be no significant difference among the average NVWM score of the three study groups.	NC=not rejected (.27) C=not rejected (.24)
2.4.2 (ADHD-hyperactive)	There will be no significant difference among the average NQR score of the three study groups.	NC=not rejected (.16) C=not rejected (.51)
2.4.3 (ADHD-	There will be no significant difference among the average VWM score of the	NC=not rejected (.09) C=not rejected (.10)

hyperactive)	three study groups.	
2.4.4 (ADHD-hyperactive)	There will be no significant difference among the average VQR score of the three study groups.	NC=not rejected (.13) C=not rejected (.31)

* NC = Not corrected for number of comorbid conditions
C = Corrected for number of comorbid conditions

The group mean difference analysis indicated significant weaknesses in a range of SB-5 scores between subjects with ADHD and the clinic control group. When the ADHD subtypes were collapsed together, a number of significant differences were supported by main effects.

Related directly to Hypotheses 1.1.1, 1.2.1, 1.3.1, the results supported a WM weakness in ADHD subjects compared to clinic control. This difference was found between the ADHD-moderate and the clinic control group for the ADHD combined and ADHD-inattentive type. Not surprising, this finding was also found when all ADHD subtypes were collapsed together (ADHD-collapsed). In addition, when the ADHD subtypes were collapsed, a group mean weakness as also found between the ADHD-moderate, compared to the ADHD-severe group.

Hypotheses related to the other SB-5 Factor scores were not rejected.

Hypotheses related to the four SB-5 subtest scores (NVWM, NVQR, VWM, VQR) also showed some significant findings. Specifically, related to Hypotheses related to NVWM, a pattern of significant findings was noted. There was a weakness found between the ADHD-moderate and clinic control groups when the ADHD subtypes were collapsed, as well as the ADHD-combined and ADHD-inattentive subtypes.

For VWM, the ADHD-moderate group had a significant weakness compared to the ADHD-severe group, when the subtypes were collapsed.

For VQR, significant weakness was found for both the ADHD-severe and ADHD-moderate groups compared to the clinic control. The finding for the ADHD-severe was found when the ADHD subtypes were collapsed, as well as in the ADHD-combined group. However the finding for the ADHD-moderate was only noted when the ADHD subtypes were collapsed.

All the hypotheses related to NVQR were not rejected.

Intra-individual Analysis

Table 4.22 presents a summary of the hypotheses statements related to intra-individual differences analysis on two of the five SB-5 Factor score and selected subtest scores. Significant results are indicated.

Table 4.22

Summary of Hypothesis Statements for intra-individual analysis.

Hypothesis Number	Statement	Finding* (power value)
3.1.1 (ADHD-collapsed)	There will be no significant difference among the average difference score of WM of the three study groups.	NC=Rejected (.73) C=Rejected (.78)
3.1.2 (ADHD-collapsed)	There will be no significant difference among the average difference score of QR of the three study groups.	NC=Not rejected (.62) C=Not rejected (.56)
3.2.1	There will be no significant difference	NC=Not rejected (.41)

(ADHD-combined)	among the average difference score of WM of the three study groups.	C=Not rejected (.49)
3.2.2 (ADHD-combined)	There will be no significant difference among the average difference score of QR of the three study groups.	NC=Not rejected (.32) C=Not rejected (.30)
3.3.1 (ADHD-inattentive)	There will be no significant difference among the average difference score of WM of the three study groups.	NC=Rejected (.59) C=Rejected (.67)
3.3.2 (ADHD-inattentive)	There will be no significant difference among the average difference score of QR of the three study groups.	NC=Not rejected (.31) C=Not rejected (.51)
3.4.1 (ADHD-hyperactive)	There will be no significant difference among the average difference score of WM of the three study groups.	NC=Not rejected (.14) C=Not rejected (36)
3.4.2 (ADHD-hyperactive)	There will be no significant difference among the average difference score of QR of the three study groups.	NC=Not rejected (.31) C=Not rejected (.28)
4.1.1 (ADHD-collapsed)	There will be no significant difference among the average difference score of NVWM of the three study groups.	NC=Rejected (.69) C=Rejected (.76)
4.1.2 (ADHD-collapsed)	There will be no significant difference among the average difference score of NVQR of the three study groups.	NC=Not rejected (.35) C=Not rejected (.39)

4.1.3 (ADHD-collapsed)	There will be no significant difference among the average difference score of VWM of the three study groups.	NC=Not rejected (.48) C=Not rejected (.43)
4.1.4 (ADHD-collapsed)	There will be no significant difference among the average difference score of VQR of the three study groups.	NC=Rejected (.78) C=Rejected (.72)
4.2.1 (ADHD-combined)	There will be no significant difference among the average difference score of NVWM of the three study groups.	NC=Not rejected (.60) C=Rejected (.79)
4.2.2 (ADHD-combined)	There will be no significant difference among the average difference score of NVQR of the three study groups.	NC=Not rejected (.36) C=Not rejected (.31)
4.2.3 (ADHD-combined)	There will be no significant difference among the average difference score of VWM of the three study groups.	NC=Not rejected (.29) C=Not rejected (.27)
4.2.4 (ADHD-combined)	There will be no significant difference among the average difference score of VQR of the three study groups.	NC=Not rejected (.26) C=Not rejected (.32)
4.3.1 (ADHD-inattentive)	There will be no significant difference among the average difference score of NVWM of the three study groups.	NC=Not rejected (.53) C=Not rejected (.54)
4.3.2 (ADHD-	There will be no significant difference among the average difference score of	NC=Not rejected (.15) C=Not rejected (.45)

inattentive)	NVQR of the three study groups.	
4.3.3 (ADHD-inattentive)	There will be no significant difference among the average difference score of VWM of the three study groups.	NC=Not rejected (.18) C=Not rejected (.26)
4.3.4 (ADHD-inattentive)	There will be no significant difference among the average difference score of VQR of the three study groups.	NC=Rejected (.86) C=Rejected (.82)
4.4.1 (ADHD-hyperactive)	There will be no significant difference among the average difference score of NVWM of the three study groups.	NC=Not rejected (.08) C=Not rejected (.14)
4.4.2 (ADHD-hyperactive)	There will be no significant difference among the average difference score of NVQR of the three study groups.	NC=Not rejected (.40) C=Not rejected (.40)
4.4.3 (ADHD-hyperactive)	There will be no significant difference among the average difference score of VWM of the three study groups.	NC=Not rejected (.14) C=Not rejected (.33)
4.4.4 (ADHD-hyperactive)	There will be no significant difference among the average difference score of VQR of the three study groups.	NC=Not rejected (.18) C=Not rejected (.15)

---

* NC = Not corrected for number of comorbid conditions
C = Corrected for number of comorbid conditions

The analysis of within individual variation, accomplished through a series of intra-individual analysis will now be summarized, as pertaining to Hypothesis 3.1.1 to 6.4.4.

Hypothesis 3.1.1, 3.2.1, 3.3.1, and 3.4.1 relate to the average size of the WM Factor score relative difference between subjects with ADHD and the clinic control. Results supported a larger relative weakness for the ADHD-moderate group versus the clinic control group, when the ADHD subtypes were collapsed together. When the ADHD subjects were broken into subtypes, this effect remained for the ADHD-inattentive type.

All hypotheses related to the relative difference in QR were not rejected.

Hypotheses related to the subtests (NVWM, NVQR, VWM, VQR) showed a total of three significant findings. For NVWM, the ADHD-moderate group showed a significantly greater relative weakness compared to the clinic control group. This was only found when the ADHD subtypes were collapsed (ADHD collapsed). For VQR, the ADHD-severe group had a larger relative weakness compared to the clinic control. This was found when the ADHD subtypes were collapsed, as well as for the ADHD-inattentive type.

All hypotheses related to the relative difference scores for NVQR and VWM were not rejected.

Chi-square Analysis

Hypotheses related to the number of individuals with a relative weakness in either the WM or QR factors were not rejected (Hypotheses 5.1.1 to 5.4.2). Table 4.21 presents a summary of the hypotheses statements related to intra-individual analysis (Chi-square) of the number of individuals in each group who exhibited significant differences (strength or weakness) on WM, QR and their respective subtests (NVWM, WVQR, VWM, and VQR). Significant results are indicated for the MSD critical value only.

Table 4.23

Summary of Chi-square analysis of significant difference counts

Hypothesis Number	Statement	Finding
5.1.1 ADHD-collapsed	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on WM among the three study groups.	Not rejected
5.1.2 ADHD-collapsed	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on QR among the three study groups.	Not rejected
5.2.1 ADHD-combined	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on WM among the three study groups.	Not rejected
5.2.2 ADHD-combined	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on QR among the three study groups.	Not rejected
5.3.1 ADHD-inattentive	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on WM among the three study groups.	Not rejected
5.3.2 ADHD-	There will be no difference in the number of subjects who meet the cut-off criteria for significant	Not rejected

inattentive	difference on QR among the three study groups.	
5.4.1 ADHD-hyperactive	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on WM among the three study groups.	Not rejected
5.4.2 ADHD-hyperactive	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on QR among the three study groups.	Not rejected
6.1.1 ADHD-collapsed	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on NVWM among the three study groups.	Not rejected
6.1.2 ADHD-collapsed	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on NVQR among the three study groups.	Not rejected
6.1.3 ADHD-collapsed	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on VWM among the three study groups.	Not rejected
6.1.4 ADHD-collapsed	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on VQR among the three study groups.	Rejected
6.2.1 ADHD-combined	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on NVWM among the three study groups.	Rejected
6.2.2	There will be no difference in the number of	Not rejected

ADHD-combined	subjects who meet the cut-off criteria for significant difference on NVQR among the three study groups.	
6.2.3 ADHD-combined	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on VWM among the three study groups.	Not rejected
6.2.4 ADHD-combined	The number of subjects who meet the cut-off criteria for significant difference on VQR among the three study groups.	Not rejected
6.3.1 ADHD-inattentive	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on NVWM among the three study groups.	Not rejected
6.3.2 ADHD-inattentive	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on NVQR among the three study groups.	Not rejected
6.3.3 ADHD-inattentive	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on VWM among the three study groups.	Not rejected
6.3.4 ADHD-inattentive	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on VQR among the three study groups.	Rejected
6.4.1 ADHD-hyperactive	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on NVWM among the three study groups.	Not rejected

6.4.2 ADHD-hyperactive	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on NVQR among the three study groups.	Not rejected
6.4.3 ADHD-hyperactive	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on VWM among the three study groups.	Not rejected
6.4.4 ADHD-hyperactive	There will be no difference in the number of subjects who meet the cut-off criteria for significant difference on VQR among the three study groups.	Not rejected

Hypotheses related to the number of individuals with a relative weakness in the four selected subtests (NVWM, NVQR, VWM, and VQR) found only three significant results. There was a significant finding for NVWM in the ADHD-combined subtype. While both the ADHD-moderate and ADHD-severe groups had close to 50% of individuals with a relative weakness, the clinic control group has a significantly fewer number of similar individuals.

For VQR hypotheses, there were two significant findings, when all ADHD subjects were collapsed and for the ADHD-inattentive subtype. When the ADHD subtypes were collapsed together, the finding was due to the clinic control group having a significant number of individuals with a relative strength when compared to the ADHD-severe and moderate groups. For the ADHD-inattentive subtype, this finding was due to a high rate of relative weakness within the ADHD-severe group.

CHAPTER FIVE: DISCUSSION

The purpose of this study is to examine the cognitive profile of children with ADHD on the SB-5. Barkley's (1997) theory of behavioural disinhibition suggests that individuals with ADHD will demonstrate weaknesses in working memory and sustained attention. Furthermore, Rapport, et al. (2001) implicate working memory deficit as the primary deficit leading to the core symptoms of ADHD. On the SB-5, the two factor scores implicated by the above theories are WM and QR.

The majority of past research has either studied ADHD as a unitary group, or examined only one subtype, typically the combined subtype. This study attempted to examine the cognitive profiles of all three subtypes of ADHD, in comparison to a clinic control. Furthermore, this study attempted to examine the role of symptom severity as a moderating factor on the cognitive profile. This has not been studied in the past in relation to ADHD subjects and their cognitive profiles.

The study adds to the body of research regarding the performance of children/adolescents with the three ADHD subtypes on the SB-5, specifically on the WM and QR factors and related subtests. In particular, it examined whether WM distinguish ADHD subjects from other clinically referred children. In addition, this study was to help determine if the three subtypes of ADHD present different distinguishing patterns of strength/weakness compared to the clinic controls.

Finally, the study investigated the intra-individual difference approach and its' diagnostic utility in identifying ADHD subtypes from other clinically referred children.

Summary of ADHD-collapsed Group Results

Since most previous studies have not divided ADHD subjects into subtypes, the results of the ADHD-collapsed group will be discussed first. Analysis at this level also increased the power of the study due to the larger sample size.

Generally speaking, collapsing all the ADHD subjects into one group resulted in a higher number of rejected hypotheses compared to when subjects were grouped by ADHD subtypes.

Group mean comparisons indicated that average WM factor scores were significantly weaker in the ADHD-moderate symptom group, compared to both the clinic control and the ADHD-severe group.

At the subtest level, the difference between mean WM scores continued in both VWM and NVWM, however the cause of the difference was different. In NVWM, the pattern of average scores was the same as for the WM factor. Thus the highest score for that subtest was the clinic control, followed by severe, and finally the moderate symptom group. The significant result occurred between the clinic control and moderate group. However, for VWM, the significant result was between the severe and moderate symptom group, as the severe symptom group's average score on this subtest was actually the highest of the three.

For the VQR subtest, both ADHD symptom groups demonstrated significant weaknesses compared to the clinic control.

Evidence of a WM weakness in ADHD subjects continued when an analysis of the average degree of weakness, based upon intra individual findings, was conducted (ANOVA). Relative weakness was found in both the verbal and nonverbal WM subtests. For the NVWM, the clinic control group showed essentially no difference between this subtest and the average of all subtest in the non-verbal scale (i.e. a mean difference score of close to zero). However, both the moderate and severe symptom groups demonstrate a relative weakness (i.e. a mean score in the positive range), with the moderate group showing the greatest weakness.

The VWM subtest's result does not support the conclusion of a relative VWM weakness as the result came about through a small weakness for the moderate group, and a relative strength in this subtest for the severe group, with the clinic control showing essentially no intra-individual variation.

All three groups, clinic control, ADHD-severe, and ADHD-moderate showed some intra-individual weakness in the VQR subtest. The significant result in this subtest came out from the ADHD-severe group however, who showed the greatest weakness, compared to the clinic control, whose weakness was marginal.

The chi-square analysis of both the VWM and NVWM did not show a significantly different pattern in number of subjects with a significant weakness or strength between any of the three study groups when all the ADHD subjects were collapsed into one group.

The results from the VQR chi-square analysis did result in a different pattern, but this was due to a comparative strength on this subtest for the clinic control group (i.e. this group had a higher number of individuals with a relative significant strength on this subtest), as opposed to any weakness in the either of the ADHD study groups.

Delineation of ADHD group results

The following section will review the significant results for each of the ADHD subtypes (ADHD-collapsed, ADHD-combined and ADHD-inattentive). In particular, it will explore the pattern of the results and discuss likely sources for each. The ADHD-hyperactive subtype group was not included as there were no significant findings from any of the analysis. This is likely due to a lack of power. The lack of power is not surprising given the small sample size of this group (n=11).

Table 5.1 summarized the significant findings from this study, by ADHD groups and study analysis.

Table 5.1

Significant findings for ADHD groups

Variables	collapsed	combined	inattentive
WM	cc>mod* sev>mod*	cc>mod	cc>mod*
NVWM	cc>mod	cc>mod	cc>mod*
VWM	sev>mod		
VQR	cc>sev cc>mod		cc>sev*
DWM	cc<mod*		cc<mod*
DNVWM	cc<mod*		
DVQR	cc<sev*		cc<sev*
VQR	cc had more cases with relative strength		sev had more cases with

	sev had more cases with a relative weakness		relative weakness than cc and mod
NVWM		sev. and mod had more cases with relative weakness than cc	

*supported by main effect
cc=clinical control
mod=ADHD-moderate
sev=ADHD-severe

Group Difference Approach

Group Difference-Factor Scores

Results of the MANOVA analysis of SB-5 factor scores supported findings from past research (Blashko, 2006; Marusiak & Janzen, 2005, Petchers, 2007) that suggests a WM deficit in children with ADHD. This result was consistent for both the ADHD-combined type (Hypothesis 1.2.1) and ADHD-inattentive (Hypothesis 1.3.1) subtypes, as well as when all ADHD subjects were collapsed (Hypothesis 1.1.1) into one group. This weakness remained evident despite the fact that the ADHD groups were being compared to a clinic control group that included children with other difficulties.

The WM result was consistent with those reported by Blashko (2006), who also found a significant weakness in the WM factor score in ADHD-combined type compared to clinic controls.

For ADHD-collapsed group, the significant difference was found between the ADHD-moderate, who had the lowest average score, compared to both ADHD-severe and clinic control. However at the subtype level, the difference between the ADHD-moderate and severe was no longer significant. Furthermore, the difference between the ADHD-moderate and control groups was stronger for the ADHD-inattentive group as it was supported by a main effect.

Overall, the ADHD-moderate group had the lowest WM score. This was a surprising result as it would be assumed that the more severely impacted individuals would have lower overall scores. It is important to note that all the WM scores remained in the average range (90-109) for all three study groups in all three ADHD groups.

The results provide evidence that a WM deficit occurs across both inattentive and combined subtypes of ADHD. Indeed, the WM deficit is a robust finding as the other studies have excluded cases with comorbid learning and other types of problems and those individuals that were on medications while these were not exclusion criteria for this study.

Group Difference-Subtest Scores

Results of group mean comparisons at the subtest level showed that when the ADHD group was divided into subtypes, some of the effects were lost.

For NVWM, the ADHD-collapsed group demonstrated a significant difference from the clinic control (Hypothesis 2.1.1). Consistent with the WM factor score results the ADHD-moderate group showed a significantly weaker score than that of the clinic control, although this was not supported by a main effect.

When the collapsed group was divided into ADHD subtypes, the result remained for both the inattentive (Hypothesis 2.3.1) and combined (Hypothesis 2.2.1) subtypes. However, the effect was strengthened, as was the case at the factor score level, for the ADHD-inattentive group who showed a main effect. For all three (collapsed, combined and inattentive) the order, from highest average score to lowest, was clinic control, ADHD-severe and ADHD-moderate. Only the NVWM score in the ADHD-moderate group of the ADHD-combined type was below the average range however.

For VWM, the ADHD-collapsed group demonstrated significantly weaker score between the severe and moderate study groups (Hypothesis 2.1.3). This was not supported by a main effect however. Furthermore, this result did not occur when subjects were broken into their subtypes.

It is notable that there was only an effect for VWM for the ADHD-collapsed group. This would suggest that the WM effect is primarily due to the NVWM component.

For VQR, the ADHD-collapsed group demonstrated an effect between the clinic control and both the moderate and severe study groups (Hypothesis 2.1.4). However this finding was not supported by a main effect. Despite significant differences between the ADHD groups and clinic control, all scores fell within the average range. Furthermore, all the significant results were not supported by a main effect prior to correcting for number of comorbid conditions.

When broken down into the ADHD subtypes, this finding occurred only in the ADHD-inattentive group, but only between the control and severe study groups (Hypothesis 2.3.4). The pattern of VQR strengths/weakness between the ADHD-inattentive study groups was different than that of the other two ADHD subtypes reported. Here the average VQR score for the severe study group was the lowest, followed by the moderate group.

Intra-individual Differences Approach

When the average difference between individual factor scores (WM and QR) and the average of all five factor scores were examined, a significant result was found for WM for the ADHD-collapsed group (Hypotheses 3.1.1). This result occurred between the clinic control and the ADHD-moderate, who had a larger WM difference score which reflected the weakness for that group. When examined at the subtype level, this result was found only in the ADHD-inattentive group (Hypothesis 3.3.1). In both analyses, the result was not supported by a main effect. As occurred with the ADHD-collapsed group, the significant result was between the moderate study group and the clinic controls. Again, the moderate symptom group showed a significantly larger WM difference score. Although the severe group also demonstrated a relative weakness, this was not significantly different from either the moderate group or clinic control. In fact, the clinic control group showed a relative strength in WM.

When the selected WM subtests were examined for average difference from the mean subtest scores of each domain (verbal or nonverbal), a significant result was found in the NVWM difference scores, in the ADHD-collapsed group (Hypothesis 4.1.1). As with the overall WM difference score, this occurred between the ADHD-moderate and clinic control. At the ADHD group level however, the effect was not found.

For the VQR difference scores, a significant result occurred in the ADHD-collapsed group (Hypothesis 4.1.4). This was due to the ADHD-severe group having a larger VQR difference score than the clinic control. It was not supported by a main effect. When the subjects were broken into subtypes however, this finding occurred only in the ADHD-inattentive subtype (Hypothesis 4.3.4).

It is interesting to note that the significant finding for NVWM and VQR in the ADHD-collapsed group was due to the clinic control group having an essentially flat profile, with the mean difference scores near zero. For the NVWM, the significant finding was between both the moderate and severe symptom groups' who's weakness were both significantly greater that the clinic control. In the case of VWM, the result was due to the moderate group having a greater relative weakness compared to the severe group. This result was only evident when number of comorbid conditions was corrected for. In spite of insufficient power, this hypothesis was rejected.

For the ADHD-inattentive subtype, both study groups had some degree of relative weakness in VQR; the severe group's average difference was significantly larger than that of the clinic control, whose difference score approached zero.

Chi-square Ahalysis-Factor Score Level

As presented earlier, there were no significant findings at the factor score level for the ADHD-collapsed group. When broken down into subtypes, there remained no significant findings.

Chi-square Analysis-Subtest Score Level

For the ADHD-collapsed group, a significant finding was found for VQR (Hypothesis 6.1.4). When broken down into subtypes, the finding occurred only for the ADHD-inattentive group (Hypothesis 6.3.4). For both of these analyses, the significant finding was due to the ADHD-severe group having the greatest number of individuals with a relative weakness compared to both moderate and clinic controls. This result proved quite robust as it occurred using the more conservative RMSD value, were just shy of 30% of the ADHD-severe subjects were identified as having a significant weakness on this subtype compared to almost 14% of the moderate and 11% of the clinic control subjects.

Even though for the ADHD-collapsed group there were no significant findings for the other three subtests, the pattern of results were different when broken into the ADHD subtypes. Specifically, for NVWM, the ADHD-combined subtype demonstrated a significant difference (Hypothesis 6.2.1). This occurred between both the ADHD-moderate and severe groups having a larger number of individuals with a relative weakness compared to the clinic control. Results showed that just under half of both study groups (41% of ADHD-severe, 47% of ADHD-moderate) had significantly weaker NVWM scores compared to their own average nonverbal scale scores. Only about 15% of the clinic control group showed a similar weakness. This result was dependent upon use of the more liberal MSD cut-off values.

Impact of Controlling for the Number of Comorbid Conditions

MANOVA

Mean Factor Scores

At the Factor score level, there were no change in the results for any of the ADHD groups (collapsed, combined, inattentive, and hyperactive).

Mean Subtest Scores

At the subtest score level, results changed in two of the four ADHD groups.

a. ADHD-collapsed: Controlling for number of comorbid conditions resulted in a strengthening of findings. There was a main effect for both the NVWM and VWM, where before there was no main effect. Interestingly, the finding of a significant difference in VQR was lost (i.e. the ADHD-severe group was no longer significantly weaker than the clinic control).

b. ADHD-combined: Controlling for number of comorbid conditions also strengthened findings. A new finding appeared where the average NVWM score for the ADHD-severe group was found to be weaker than that of the clinic control. In VWM, there was a significant difference found between the ADHD-severe and both the clinic control and ADHD-moderate study groups.

c. There were no changes in the results in either the ADHD-inattentive or ADHD-hyperactive groups.

ANOVA

Factor Difference Score

As with the group mean analysis, there were no changes in the results due to controlling for number of comorbid conditions at the factor score level.

Subtest Difference Score

For the average subtest score difference analysis, there were some changes in the results. These changes likewise followed the same pattern as those found in the group mean analysis, and are as follows:

a. ADHD-collapsed: Controlling for number of comorbid conditions resulted in a finding of a larger weakness in NVWM between the ADHD-severe group, compared to the clinic control. Also, there was a finding for VWM, with the ADHD-moderate group having a larger weakness than the ADHD-severe group.

b. ADHD-combined: Controlling for number of comorbid conditions resulted in a significant finding, where there had been no significant finding when uncorrected. The average NVWM difference scores between both ADHD-severe and ADHD-moderate were larger than that for the clinic control.

c. The same pattern was found as in the MANOVA results, controlling for number of comorbid conditions resulted in no change in the results at the subtest level for either the ADHD-inattentive or ADHD-hyperactive groups.

Thus, controlling for number of comorbid conditions resulted in changes only at subtest level. It is suspected that this may be due to the lower reliability at the subtest level compared to the factor level. Removing the variability due to the comorbidity, lessened the unaccounted variance, having a greater impact at the subtest level due to its' greater variability.

However, because correcting for comorbid conditions was done by simply counting the number of comorbid conditions, as opposed to type of comorbid conditions, further interpretation of the results are not warranted. Furthermore the assumption is that the each comorbid condition impacts upon an individual's cognitive performance in the same way, and that the impact is additive.

Methodological Considerations

Intra-individual Difference Approach

The intra-individual difference approach attempts to examine the relative strengths and weaknesses within an individual's cognitive profile. In other words, is the cognitive profile relatively flat, where all areas measured are at about the same level, or are there significant relative strengths or weaknesses? One interesting feature of this approach is that it is not affected by the overall level of cognitive functioning of the individual. Research of learning difficulties in the gifted population is one example of the use of relative weaknesses in determining the need for remediation. The generation of a difference score is a methodology put forth by researchers and has been applied to several of the Wechsler series of intelligence test (Naglieri, 1993) and has been postulated for use on the SB (Naglieri & Goldstein, 2006) as well. In particular, Nagleri (1993), with the use of a set of cut-off values, has advocated this approach to use at a case level where one can determine if a particular deviation reaches the significant value to be declared a relative weakness. Roid (2003d) has provided sets of theses critical values for SB measures.

The intra-individual difference approach utilized in this study had two aspects: examination of the size of the difference (through the use of 1-way ANOVAs), and examination of the pattern of deviations, strengths or weaknesses, via tallying the number of individuals in each area (through the use of a series of chi-squares). The analysis of the size of the difference score indicates, at a group level, whether there is a relative strength, as indicated by a negative score, a relative weakness, as indicated by a positive score, or no difference, as indicated by a mean difference score close to zero. The use of a chi-square analysis provides a more detailed examination of this pattern. For example, a mean difference score of zero could have been generated by all cases falling in the no difference range, or a situation whereby there are an equal number of cases with a relative strength and equal number of cases with a relative weakness, or some other combination.

Subtype Comparisons

Although the study could have compared the three subtypes to one another, it was decided that all comparisons would be performed between each subtype to the clinic controls. There were two prime reasons for this decision. The first was that adding this level of comparison would have reduced our ability to make the severe-moderate symptom comparisons, which were deemed more important at this time. The second reason was because it was felt that the more important clinical decision is typically with contrasting between whether or not an individual has ADHD or another condition, rather than what subtype they may have.

Discussion of the Clinic Control Group

The clinic control group was made up of individuals who did not meet any of the study's criteria for ADHD. This group consisted of subjects referred to the clinic for assessment for a range of reasons which could include psychological/behavioural, or academic issues, as well as some who were being assessed for giftedness.

In reviewing the SB-5 factor and subtest scores two observations were made. First, this group had scores in the average range across the factor and subtests examined. Second, this group had a near zero score for the intra-individual analyses.

Even though this group consisted of subjects referred for clinical reasons, it is suspected that the inclusion of subjects referred to evaluate giftedness may have elevated the overall average for this group.

The near zero intra-individual scores indicates that the subject's profile on the SB-5 is flat. That is, there are not relative strengths or weaknesses in the factor or subtests scores. This is a notable contrast to the ADHD groups, whose intra-individual scores showed general weakness in the WM factor scores, as well as a number of subtests.

Severity of ADHD Symptoms

The decision not to combine the ADHD-severe group (BASC groups A, D, G) with ADHD-moderate group (BASC groups B, C, E, F, and H) was made post-hoc. There were two rationales for this, clinical and statistical.

Clinical evidence includes significant differences on the BASC/BASC-2. The ADHD-severe group had higher symptom, and lower adaptive, ratings than either the ADHD-moderate or Clinic Control groups. In addition, the percentage of cases of ADHD subtypes within each symptom level group was different. The percentage of ADHD-severe subjects in each subtype was as follows: 48%, 40%, and 12% for ADHD combined, ADHD-inattentive, and ADHD-hyperactive respectively. Whereas for ADHD-moderate, the percentages were 29%, 64%, and 7% for ADHD combined, ADHD-inattentive, and ADHD-hyperactive respectively. The prevalence rates for the three subtypes varies from those found by Szatmari (1992), particularly for the ADHD-moderate study group, as ADHD-inattentive type is usually the least common subtype found.

Statistical evidence supporting the treating of these two groups separately arises from the BASC/BASC-2 designation for "At-risk" (60-69) and "Clinically Significant" (70+). The BASC/BASC-2 differentiates between score elevations between one to two standard deviations, and those above two standard deviations. Not separating these two groups would be ignoring the purported differences between these two levels of symptoms, as recommended by the BASC's developers.

Effect of Correcting for Number of Comorbid Conditions

As indicated in chapter three, an attempt to account for comorbid conditions was made based upon the number of conditions as opposed to the type. This was due to difficulties in identifying specific comorbid conditions from information presented in the various files reviewed. Overall, controlling for number of comorbid conditions did not alter most of the results, with some exceptions. In general, this statistical correction did improve the power values for most of the analyses.

Discussion Related to the Questions Raised by this Study

Group Difference-Factor Scores

The first question poised by this study was what, if any, differences exist between the five SB-5 factor scores for the three subtypes of ADHD compared to other clinical cases? And if so, is a WM deficit evident across all three ADHD subtypes?

Results support a working memory factor score deficit in both the ADHD-combined type and ADHD-inattentive groups, although it is greatest in the ADHD-inattentive group, where it was supported by a main effect. Further, for both ADHD subtypes the difference occurred in the moderate, but not the severe study group. Indeed, the ADHD-moderate study group consistently had the lowest WM factor score of the three study groups in all the ADHD subtypes.

Unfortunately, the results from this study do not support ruling out other factor score deficits, due to the generally low power scores for most of these factors.

Group Difference-Subtest Scores

What, if any, differences exist between the four subtest scores comprising the WM and QR factors of the SB-5, compared to other clinical cases? Is the WM deficit across both verbal and nonverbal areas, as well as all subtypes?

At the subtest level, the WM deficit effect remained for the collapsed, combined and inattentive ADHD groups, again with variations. The weak effect for VWM that was found when all ADHD subjects were collapsed together disappeared when the subjects were divided up into their respective subtypes. NVWM deficits were strongest, particularly in the ADHD-inattentive group.

The VQR weakness identified in the ADHD-collapsed group was found only in the ADHD-inattentive group, between the ADHD-severe and stronger clinic control study groups. Interestingly, for the ADHD-combined type, the VQR score was higher, close to that of the clinic control.

Difference Score Analysis-Factor Score Level

Is there a difference between each of the three subtypes of ADHD, compared to other clinically referred student, in average difference score for the WM and QR relative to the individual's overall profile on the SB-5?

There was a greater degree of weakness identified in the ADHD-collapsed group for the WM factor. This difference, which appeared between the clinic control and ADHD-moderate study group appears driven primarily by the ADHD-inattentive group, although the ADHD-combined group showed a very similar pattern, suggesting that the difference in the results for these two subtypes is marginal.

Difference Score Analysis-Subtest Score Level

Is there a difference between each of the three subtypes of ADHD, compared to other clinically referred student, in average difference score for NVWM and NVQR relative to the other nonverbal subtest scores and VWM and VQR relative to the other verbal subtest scores?

Results showed a notable degree of difference between the ADHD-collapsed group and the two ADHD subtypes. There was a significantly larger degree of relative difference in NVWM only when all ADHD subjects were collapsed together. A significantly larger degree of relative difference for VQR was found for the ADHD-collapsed and ADHD-inattentive subtypes.

Chi-square Analysis

The final part of this study was a chi-square analysis based upon the number of individuals whose subtest scores met the critical value for a significant difference for the two factor scores relative to the overall mean, or the subtest score relative to their respective verbal or nonverbal means. The first question addressed by this analysis was: do the ADHD subtypes exhibit different patterns, with different number of cases with relative strength, no difference, and relative weakness, compared to other clinical cases? Results of the chi-square analysis at the factor score level were not significant.

The second set of chi-square analysis examined the same issue at the subtest level. Thus this set examined the ADHD subtypes for different patterns, with different number of cases with relative strength, no difference, and relative weakness, when compared to other clinical cases for NVWM, VWM, NVQR and VQR.

There were two significant results from this series, differentiating ADHD-combined type from ADHD-inattentive. Within the ADHD-combined group, both the ADHD-severe and ADHD moderate symptom groups had more cases with a relative weakness in NVWM than the clinic control.

Within the ADHD-inattentive group, the ADHD-severe symptom group had more cases with a relative weakness in VQR than both the ADHD-moderate symptom and clinic control groups.

Implications of Findings

WM Deficits

The pattern of results from this study supports a general trend of WM weakness between ADHD subjects compared to the clinic control. Evidence of an overall weakness extended beyond simple group mean comparisons to greater average intra-individual weakness (ANOVAs), as well as significantly higher absolute number of individual's with significant relative weakness (Chi-square). The WM weakness was not, however, consistent for each ADHD subtype, as well as symptom severity groups.

The SB-5 WM factor score weakness within the ADHD-collapsed group replicates results from the other studies that did not differentiate between subtypes (Marusiak & Janzen, 2005; Petchers, 2007). The results for the ADHD-combined group were also consistent with Blashko's (2006) results. Adding to these three previous studies are the findings of a significant weakness in this factor score for ADHD-inattentive subjects as well.

At the subtest level, the weakness found in the WM factor scores appear to be driven by the NVWM scores of both the ADHD-combined and inattentive groups. A similar result was found by Blashko (2006), when she examined ADHD-combined subjects. Significant NVWM weakness within the ADHD-I group was the strongest however, as it was the only one supported by post hoc analysis. Controlling for number of comorbid conditions strengthen the effect in the ADHD-combined type group, showing a significant weakness in the subtest for both ADHD symptom groups (severe and moderate). This is consistent with results from Blashko (2006), who found a similar result for this subtype.

However, the results for the ADHD-combined group differed from that of Blashko (2006) at the VWM subtest level. In that study, no significant difference in the VWM average was found between ADHD-combined group and the clinical controls. In this study however, an effect in VWM was found, caused by a relative strength in the ADHD-severe group, compared to the clinic control group. It is important to note that this occurred only when corrected for number of comorbid conditions. The difference in the results for this subtest is likely due to this study's separation of the severe and moderate groups from one another. In Blashko's study, there was no such separation.

The VWM finding suggests that VWM is operating differently that NVWM. Whereas the clinic control group had the strongest score in NVWM, in VWM, it is the severe symptom group. It is important to note that the relative strength of the severe symptom group was only found when number of comorbid conditions was corrected for.

The weakness in NVWM is consistent with those found by others (Blashko, 2005; Petchers, 2007) for the SB-5. Marusiak & Janzen (2005) also found weakness in NVWM scores compared to VWM within ADHD subjects. In addition, it adds to the growing volume of studies that have found similar deficits in ADHD populations using other cognitive measures of working memory (Martinussen, et al., 2005; Lacene, 2003; Mayes and Calhoun, 2006). These results are consistent with that predicted by the working memory deficit model of ADHD as proposed by Rapport, Chung, Shore, & Isaacs (2000 and 2001), as well as Barkley's prediction of a WM deficit within his model (1997a).

The NVWM subtest comprises of two different tasks, Delayed Response and Block taping. Delayed Response is the more simple of the two, and can begin with a simple shell game, where the subject find a hidden object under a cup that has been rearranged. Roid (2003c) identifies this task as measuring visual short-term memory and attention. Sergeant, Geurts, Huijbregts, Scheres & Oosterlaan (2003) argued that WM may represent an activated long-term memory responding to selective attention demands. In this sense they also suggest that working memory includes an attention component. For this subtest, it does not seem likely that the Central Executive is overly involved. However others (Leffard, et al, 2006) suggest that this task is better described as a measure of object permanence, visual tracking and one-on-one relations. The higher order testlet on NVWM is Block Tapping. Subjects reproduce a demonstrated sequence of tapping upon series of coloured block arranged in two rows. The task is made more difficult at higher levels by requiring subjects to transform the demonstrated order of taps into one which follows a described rule. At the lower level of this testlet, the tasks are a good measure of the Visual-spatial Sketchpad (Roid, 2003c). However, at a more advanced level, the testlet is likely tapping into the Central Executive and Episodic Buffer as well. Additionally, the requirement of receiving and understanding the verbally presented rules for the transformations to be made, may implicate the involvement of VWM as well.

For the SB-5, where an individual starts a subtest in determined by performance on the routing tasks. Leffard et al. (2006) suggested that there are different underlying processes involved in the two testlets of VWM. They argue that Memory for Sentences is a measure of phonological rehearsal, whereas Last Word is a measure of transformation. Thus, Last Word could be interpreted as placing a greater demand upon the Central Executive. For NVWM, even though there is only one task, the processes involved in it changes as the items progress. According to Leffard et al. (2006), the earlier items of the Block Tapping activity requires simple rehearsal, whereas the later items involve transformations. As with VWM, the later items place a greater demand upon the Central Executive. Thus, for a particular subject, the NVWM score may only involve the lower level task, which likely places most of the demand upon the sketch-pad, as opposed to a higher level processing making more demands of the central executive and episodic buffer. Thus this study cannot infer specifically to what extent each of the components of working memory (Visual-spatial Sketchpad, Phonological Loop, Central Executive, or Episodic Buffer) is implicated in the various ADHD subtypes.

Implications Regarding VQR Deficits

A weakness in VQR was also found in this study, occurring in both the collapsed and ADHD-inattentive groups. This is in contrast to Petchers' (2007) findings for undifferentiated ADHD subjects. As opposed to the WM results, this VQR difference was driven by a weakness in the ADHD-severe group rather than the moderate group as occurred in the majority of the WM differences found. No significant result was found in the ADHD-combined subtype group. The VQR weakness was quite strong, supported by post hoc analysis and occurring at both the group comparison level (MANOVA) and intra-individual levels (ANOVA and chi-square).

According to Roid (2003e), VQR targets mathematical knowledge, sustained attention, and producing verbal responses. Gathercole et al. (2003) found a strong correlation between working memory scores and mathematical scores on a national curriculum test. Thus, one possible explanation of the VQR weakness in this group may be that it is a result of the underlying WM weakness. However, since the pattern was not the same as the WM results, the relationship is likely more complicated. Another possible explanation could be weaker overall math knowledge in the inattentive group, possibly due to an overrepresentation of math based LD. Regardless, this VQR weakness differentiated the ADHD-I group from the ADHD-C when they were compared to the clinic control.

Implications Regarding Severe/moderate Differentiation

An unanticipated result from this study involved the pattern of differences between the ADHD-severe and moderate groups, compared to the clinic control. It was anticipated that WM deficits would be unaffected by symptom severity (as measured by the Abbreviated Conners' Rating Scale), as was found by Barnett et al. (2001). This study used two computerized versions of spatial memory and spatial working memory. The spatial working memory task was a computerized version of the Corsi Block Tapping Task, and thus similar to the SB-5's Block Tapping task (NVWM).

However, results from this study were opposite; with the vast amount of the significant findings in this study arising out of the ADHD-moderate group. This group had the lowest average factor scores across all measures. This remained true at the subtest level, where the moderate group consistently had the lowest scores for VWM and NVWM. In terms of the QR factor, the VQR score of the ADHD-severe group did follow anticipated patterns, being the lowest in the ADHD-inattentive group only.

Although the ADHD-severe children had greater elevations in the Hyperactivity and/or Attention Problem scales, this study did not look into possible variation between the two symptom severity groups in terms of other symptoms. Since the severe group had the highest BSI score on the BASC/BASC-2, there could also be greater elevations in other areas in addition to the Hyperactive and/or Attention Problems scales.

None of the three previous studies using similar samples separated out the severe from the moderate symptom (Blashko, 2005; Petchers, 2007; Marusiak & Janzen, 2005). By separating out the symptom groups, this study removed some of the variability from the ADHD sample. Failure to account for symptom severity may also be found to account for some variations in results in ADHD research.

Certainly, this study's results suggest that it may be useful for researchers to investigate variation between groups of ADHD subjects based upon severity of symptoms. Classification/diagnosis based upon the degree of symptom severity (dimensional) is common in clinical research. Although not as commonly found in the ADHD literature to date, some studies have reported results that support its' use (Volk, Neiman & Todd, 2005).

Some of the Multimodal Treatment Study of Children with ADHD (MTA) research articles has discussed the role of symptom severity as a moderating factor that may impact treatment effectiveness and outcome. Santosh, et al.

(2005) suggested that children with milder ADHD symptomatology may be better treated with non-pharmacological interventions.

Implications for Subtype Differentiations

Results from this study showed a different pattern of results between the ADHD-combined and ADHD-inattentive subtypes, suggesting the validity of separating ADHD subjects into these two subtypes. Unfortunately, the ADHD-hyperactive group was found to be too small, and thus the results cannot be considered to either support or reject this subtype. The low incidence of ADHD-H subtype within this study is not surprising as this subtype's occurrence rate in children beyond age six is low (Naglieri & Goldstein, 2006).

Generally, the ADHD-combined subtype group demonstrated weaknesses only in the area of working memory. However, the ADHD-inattentive group demonstrated weakness in both working memory and quantitative reasoning.

At the level of factor and subtest scores, two findings differentiated these two subtypes. As mentioned earlier, group mean comparisons found that both subtypes shared an overall weakness in WM. This weakness occurred in the NVWM subtest. These effects on WM were supported by main effects in the ADHD-inattentive type only. The other difference between these subtypes occurred in VQR, with only the ADHD-inattentive group showed a deficit in this subtest.

At the intra-individual level there were three results that differentiated the two subtype groups. For the inattentive subtype, there was a significant intra-individual weakness found in WM, but not at either the VWM or NVWM subtest level. When looking at the combined subtype group, this result did not occur at the factor score level, but did at the NVWM subtest level, when corrected for number of comorbid conditions. This is a somewhat unusual pattern of finding. It is possible that the ADHD-combined group had specific relative weakness in NVWM only, whereas the inattentive group had a less pronounced weakness in both VWM and NVWM.

The third result occurred with a relative, intra-individual weakness in VQR. In addition to the finding in the ADHD-inattentive group of an absolute weakness in VQR, this subtype demonstrated an intra-individual weakness in comparison to other verbal scores. The combined subtype demonstrated no such intra-individual weakness in VQR.

For the ADHD-combined subtype, the NVWM remained a defining weakness for this group, which translated into a significantly greater number (just short of 50%) of both moderate and severe symptom members demonstrating intra-individual weaknesses.

Results of this study support the need to differentiate between the subtypes. In comparing the overall results between the ADHD-subtypes to when they were collapsed together, it is evident that doing so results in a blending of characteristics of both subtypes together. Although both subtypes exhibited significant weaknesses in WM, particularly NVWM, they differed from one another in terms of a weakness in VQR.

Recent research has provided support for this separation between the subtypes (Geurts, Verte, Oosterlann, Roeyers, & Sergeant, 2004; Riccio, Homack, Jarratt, & Wolfe, 2006; Booth, Carlson, & Tucker, 2007). Naglieri & Goldstein (2006) also argue that subtype differentiation is important, due to different underlying deficits. They maintain that this differentiation has utility in education planning and support. This study did not directly compare the three ADHD subtypes to one another.

This study found that the pattern of working memory deficits varied between the subtypes when they are compared to a clinic control. Further research would be beneficial to clarify the patterns observed in this study by directly comparing the three subtypes to one another.

Lastly, it is perhaps important to note that the differentiation of ADHD subtypes with and without hyperactivity is a relatively recent development made in the DSM-III (APA, 1980). Barkely (1997a) in his review of the history of the diagnosis of ADHD, postulates that ADHD-I could actually represent a separate and distinct disorder. Results from this study may provide additional support for the continued investigation of the uniqueness of ADHD-I from the other two subtypes. Indeed, the symptomatology of ADHD-I may be better conceptualized as a learning disorder. Indeed some studies have found a higher rate of comorbid learning disabilities in ADHD-I groups (Weiss, Worling & Wasdell, 2003). Some studies have concluded that WM deficits differentiate between comorbid language disorders rather than ADHD subtypes (Jonsdottir, Bouma, Sergeant & Scherder, 2004). Yet other researchers have suggested that LD and ADHD be conceptualized as interrelated disorders on a continuum that commonly coexist (Mayes, Calhoun, Crowell, 2000).

Implications for Cognitive Assessment of ADHD Subjects

Psychological assessments serves to provide information in order to make informed decisions regarding special needs placement, answer diagnostic questions, plan support/remedial planning, and evaluate progress (Sattler 2001). Psychological assessments frequently include the assessment of cognitive abilities, of which the SB-5 is one.

The results of this study has two implications regarding the use of the SB-5 on ADHD subjects, one is diagnostic, the other interpretive.

The results from this study support past research that suggests a working memory deficit in subjects with ADHD. The WM deficit is manifested in two aspects. There is an absolute WM deficit when ADHD children are compared to other clinically referred children. In addition, the intra-individual difference analysis suggests that there is a relative WM weakness within the child's own cognitive profile.

Although subtest scores are generally regarded as less reliable than factor scores (Sattler, 2001), the lack of significant findings in the VWM within the ADHD subtypes might indicate that ADHD children's WM deficit occurs primarily in the NVWM.

Although group mean differences have been established by others Blashko's, 2006; Marusiak & Janzen, 2005; Petchers, 2007), as well as suggested by Roid (2003d), the analysis of intra-individual differences provides more clinically useful information in regards to WM deficits in individual children with ADHD. Clinicians frequently look for relative weaknesses in specific subtests both to make diagnostic, as well as program decisions. Understanding relative strengths and weaknesses help clinicians make recommendations regarding compensatory strategies and remedial intervention. This study suggests that relative weakness in WM is observable at an intra-individual level, which could support the recommendations of remedial programs aimed at improving WM functioning (Gathercole & Alloway, 2008).

However, this study continues to show that the WM deficit found in ADHD children is complicated, thus it is not useful from a diagnostic perspective. Thus a finding of a WM deficit should not be used as a sole criteria for diagnosis of ADHD or any of its' subtypes.

Implications for Research

Results from this study have a number of implications for future research regarding causality and treatment effectiveness. Differences in cognitive profiles between both ADHD subtypes and symptom severity levels suggest that the assumption of the role of a single core deficit in the development of ADHD may not be found. This in turn may support the more resent position by some researchers that there exist multiple neurological pathways towards the development of the disorder (Sonuga-Barke, 2004).

In terms of treatment effectiveness studies, many if not most, have failed to account for various subtypes or symptom severity levels. The MTA did recognize the importance of symptom severity, controlling for this via random assignment (Swanson, et al., 2008b). The effectiveness of various treatment options, notably those dealing with WM training in particular, may vary between ADHD subtypes and/or severity levels. This is a possible weakness of studies that do not account for these two variables, such as Klingberg, et al (2005).

Limitations

Archival studies are limited by the amount and accuracy of the information that had been collected. To the extent that some crucial information might be missing, there are no provisions to amend that. All the assessments were completed by clinicians in training and thus the quality of the assessment and conclusions would vary.

As mentioned earlier in this section, the small number of subjects in the ADHD-Hyperactive type group limits the interpretation of results for that group. This may be primarily due to the fact that referrals for hyperactive children may have been made to school or medical/psychiatric facilities, due to the more disruptive nature of this behavioural group. Furthermore, the occurrence rate for ADHD-H likely diminishes with age as this feature tends to moderate as the individual approaches adolescence (APD, 2000).

Delimitations

Delimitations of this study include the use of a clinic population. The study population is a convenience sample, those children that had been referred to the University of Alberta Education Clinic. It is suspected that the types of subjects referred to the university's clinic tends to under represent the more severely affected cases which would normally be referred for assessment either through the school or health services systems. A further delimitation to using this population of subjects is the fact that it is not randomized, the clinic control group does not represent "normal" subjects, and the full range of children with ADHD is likely not represented. Further, an age restriction was implemented for this study to school aged subjects.

Two other delimiters are comorbid conditions and ADHD medication use. This study did not eliminate subjects with comorbid conditions. However, the analysis of comorbidity was only partial as it only took into account the number of comorbid conditions. This approach was taken due to the lack of confidence the researchers had in the consistency between individual reports regarding existence and type of comorbid conditions.

For the issue of ADHD medication use, there was a similar concern. Furthermore, where ADHD medication use was noted, there was a lack of information regarding whether or not it had been administered at the time of the assessment. Thus, there was no exclusion based upon medication use.

Because of the nature of the measurements used, conclusions can only be attributed to the general construct of working memory, as it is measured by the SB-5, as opposed to specific components such as Central Executive, Episodic Buffer, Phonological Loop, or the Visuospatial Sketchpad.

Finally, many of the hypotheses tested had insufficient power (refer to Appendix tables 5a to 6b).

Further Study

Given the unexpected differences found between the ADHD-moderate and ADHD-severe groups, further investigation into the makeup of these two groups is warranted. In particular, it is queried whether the two groups truly represent different levels of ADHD symptoms, or if one is better described as subjects with symptoms caused by other conditions. In this sense, future research may wish to investigate the occurrence of other symptoms or conditions present between the different subtypes and severity levels.

Since correcting for the number of comorbid conditions already produced more significant results in some of the analysis, it is suspected that future studies that would use specific comorbid conditions (such as math LD, reading LD, mood disorders, etc.) as a grouping variable may further clarify the roles these play in the cognitive profile differences among the ADHD subtypes.

As this study did not examine the differences between the subtypes directly, subsequent research could repeat this design in order to compare the ADHD subtypes directly to one another.

REFERENCES

Achenbach, T. M. (1991). *Integrative guide to the 1991 CBCL/4-18, YSR, and TRF Profiles*. Burlington, VT: University of Vermont.

Acosta, M.T., Arcos-Burgos, M., & Muenke, M. (2004). Attention deficit/hyperactivity disorder (ADHD): Complex phenotype, simple genotype? *Genetic Medicine, 6,* 1-15.

American Psychiatric Association (1968). *Diagnostic and Statistical Manual of Mental Disorders, Second Edition.* Washington, DC: Author.

American Psychiatric Association (1980). *Diagnostic and Statistical Manual of Mental Disorders, Third Edition.* Washington, DC: Author.

American Psychiatric Association (1987). *Diagnostic and Statistical Manual of Mental Disorders, Third Edition-Revised.* Washington, DC: Author.

American Psychiatric Association (2000). *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision.* Washington, DC: Author.

Anastopoulos, A.D., & Shelton, T.L. (2001). *Assessing attention-deficit/hyperactivity disorder.* Dordrecht, Netherlands: Kluwer Academic Publishers.

Anderson, J.C., Williams, S., McGee, R., & Silva, P. (1987). DSM-III disorders in preadolescent children: Prevalence in a large sample from the general population. *Archives of General Psychiatry, 44,* 69-76.

Aron, A.R., & Poldrack, R.A. (2005). The cognitive neuroscience of response inhibition: Relevance for genetic research in attention-deficit/hyperactivity disorder. *Biological Psychiatry, 57,* 1285-1295.

Atkinson, R.C., & Shiffrin, R.M. (1968). Human memory: a proposed system and its control processes. In K.W. Spence, & J.T. Spence (Eds.), *The psychology of learning and motivation: Advances in research and theory* (pp. 889-895). New York: Academic Press.

August, G.J, & Holmes, C.S. (1984). Behavioral and academic achievement in hyperactive subgroups and learning disabled boys. *American Journal of Disabled Children, 138,* 1025-1029.

August, G.J., Stewart, M.A., & Holmes, C.S. (1983). A four-year follow-up of hyperactive boys with and without conduct disorder. *British Journal of Psychiatry, 143,* 192-198.

Baddeley, A.D. (1986). *Working Memory.* Oxford: Oxford University Press.

Baddeley, A.D. (1993). Working memory or working attention? In A.D. Baddeley & L. Weiskrantz (Eds.), *Attention: Selection, awareness and control* (pp 152-170). Oxford: Clarendon Press.

Baddeley, A.D. (1996a). Exploring the central executive. *The Quarterly Journal of Experimental Psychology, 49A,* 5-28.

Baddeley, A.D. (1996b). The fractionation of working memory. *Proc Natl Acad Sci, USA, A93,* 13468-13472.

Baddeley, A.D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences, 4-11,* 417-423.

Baddeley, A.D. (2003). Working Memory: looking back and forward. *Nature Reviews: Neuroscience, 4,* 829-839.

Baddeley, A.D., Gathercole, S.E., & Papagno, C. (1998). The phonological loop as a language learning device. *Psychological Review, 105,* 158-173.

Baddeley, A.D., & Hitch, G.J. (1974). Working Memory. In G.A. Bower (Ed.), *The psychology of learning and motivation: Recent advances in learning and motivation* (pp. 47-89). New York: Academic Press.

Barkley, R.A. (1997a). *ADHD and the nature of self-control.* New York: The Guilford Press.

Barkley, R.A. (1997b). Behavioural inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin, 121,* 65-94.

Barkley, R.A. (1998). *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment (2^{nd} ed.).* New York: The Guilford Press.

Barkley, R.A. (2004). Adolescents with attention-deficit/hyperactivity disorder: An overview of empirically based treatments. *Journal of Psychiatric Practice, 10(1),* 39-56.

Barkley, R.A. & Biederman, J. (1997). Towards a broader definition of the age-of-onset criteria for attention-deficit hyperactivity disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 36,* 1204-1210.

Barkley, R.A., Edwards, G., Laneri, M., Fletcher, K., & Metevia, L. (2001). Executive functioning, temporal discounting, and sense of time in adolescents with attention deficit-hyperactivity disorder (ADHD) and oppositional defiant disorder (ODD). *Journal of Abnormal Child Psychology, 29,* 541-556.

Barnett, R., Maruff, P., Vance, A., Luk, E.S.L., Costin, J., Wood, C., & Pantelis, C. (2001). Abnormal executive function in attention deficit hyperactivity disorder: the effect of stimulant medication and age on spatial memory. *Psychological Medicine, 31,* 1107-1115.

Baxter, J.K. (2000). The relationship of attention deficit disorder and the internalizing dimension in males, ages 9-0 to 11-11. *Dissertation Abstracts International Section A: Humanities and Social Science, 61*, 1287.

Biederman, J. (2005). Attention-deficit/hyperactivity disorder: A selective overview. *Biological Psychiatry, 57,* 1215-1220.

Biederman, J., Faraone, S.V., Mick, E., Wozniak, J., Chen, L., Ouellettee, C., Marrs, A., Moore, P., Garcia, J., Mennin, D., & Lelon, E. (1996). Attention-deficit hyperactivity disorder and juvenile mania: An overlooked comorbidity? *Journal of American Academy of Child and Adolescent Psychiatry, 35,* 997-1008.

Biederman, J., Faraone, S.V., Milberger, S., Curtis, S., Chen, L., Marrs, A., Ouellette, C., Moore, P., & Spencer, T. (1996). Predictors of persistence and remission of ADHD: Results from a four-year prospective follow-up study of ADHD children. *Journal of American Child and Adolescent Psychiatry, 35,* 343-351.

Biederman, J., Newcorn, J., & Sprich, S. (1991). Comorbidity of attention deficit hyperactivity disorder with conduct, depressive, anxiety, and other disorders. *American Journal of Psychiatry, 148*, 564-577.

Bird, H.R., Gould, M.S., & Staghezza, B.M. (1993). Patterns of diagnostic comorbidity in a community sample of children ages 9 through 16. *Journal of the American Academy of Child and Adolescent Psychiatry, 32,* 361-368.

Blashko, P.C. (2006). *Performance of Children with Attention Deficit Hyperactivity Disorder-Combined subtype on the Stanford-Binet Intelligence Scale, Fifth Edition.* Unpublished Doctorial Thesis, University of Alberta.

Booth, J.E., Carlson, C.L., & Tucker, D.M. (2007). Performance on a neurocognitive measure of alternating differentiates ADHD combined and inattentive subtypes: A preliminary report. *Archives of Clinical Neuropsychology, 22,* 423-432.

Braver, T. S., Cohen, J. D., Nystrom, L. E., Jonides, J., Smith, E. E., & Noll, D.C. (1997). A parametric study of prefrontal cortex involvement in human working memory. *Neuroimaging, 5,* 49-62.

Brown, L.L., & Hammill, D.D. (1983). *Behaviour Rating Profile.* Austin, TX: Pro-Ed.

Brown, T.E. (2002). DSM-IV: ADHD and executive function impairments. *Advanced Studies in Medicine, 2(25),* 910-914.

Burgess, N., & Hitch, G.L. (1999). Memory for serial order: A network model of the phonological loop and its timing. *Psychological Review, 106*, 551-581.

Burns, T.G., & O'Leary, S. D. (2004). Wechsler Intelligence Scale for Children-IV: Test review. *Applied Neuropsychology, 11,* 235-238.

Bush, G., Valera, E., & Seidman, L.J. (2005). Functional neuroimaging of attention deficit/hyperactivity disorder: A review and suggested future directions. *Biological Psychiatry, 57,* 1273-1284.

Campbell, S.B., & Werry, J.S. (1986). Attention deficit disorder (hyperactivity). In H.C. Quay, & J.S. Werry (Eds.), *Psychopathologic disorders of childhood* (pp. 1-35). New York: Wiley & Sons.

Cantwell, D.P. (1996). Attention deficit disorder: A review of the past 10 years. *Journal of the American Academy of Child and Adolescent Psychiatry, 35*, 978-987.

Carlson, S., Martinkauppi, S., Rama, P., Salli, E., Korvenoja, A., & Aronen, H. (1998). Distribution of cortical activation during visuospatial n-back tasks as revealed by functional magnetic resonance imaging. *Cerebral Cortex, 8,* 743-752.

Carroll, J.B. (1993). *Human cognitive abilities: A survey of factor-analytical studies.* New York: Cambridge University Press.

Casey, B.J., Castellanos, F.X., Giedd, J.N., Marsh, W.L., Hamburger, S.D., Schubert, A.B., et al. (1997). Implication of right frontostriatal circuitry in response inhibition and attention-deficit/hyperactivity disorder. *Child & Adolescent Psychiatry, 36,* 374-383.

Castellanos, F.X., Giedd, J.N., Hamburger, S.D., Marsh, J.N., & Rapoport, J.L. (1996). Brain morphology in Tourette's syndrome: The influence of comorbid attention-deficit hyperactivity disorder. *Neurology, 47,* 1581-1583.

Castellanos, F.X.., Lee, P.P., Sharp, W., Jeffries, N.O., Greenstein, D.K., Clasen, L.S., et al. (2002). Developmental trajectories of brain volume abnormalities in children and adolescents with attention-deficit/hyperactivity disorder. *JAMA, 28,* 1740-1748.

Castellanos, F.X., & Tannock, R. (2002). Neuroscience of attention-deficit/hyperactivity disorder: The search for endophenotypes. *Nature Review Neuroscience, 3,* 617-628.

Chess, S. (1960). Diagnosis and treatment of the hyperactive child. *New York State Journal of Medicine, 60,* 2379-2385.

Conners, C.K. (1997). *Conners' Rating Scales-Revised, Users Manual.* Multi-Health Systems Inc.: Toronto, ON.

Cuff, S.P., Moore, C.G., & McKeown, R.E. (2005). Prevalence and correlates of ADHD symptoms in the National Health Interview Survey. *Journal of Attention Disorders, 9(2),* 392-401.

Davis, F.B. (1959). Interpretation of differences among averages and individual test scores. *Journal of Educational Psychology, 50,* 162-170.

Davis, K.J. (2001). Comparison of the Behavior Assessment System for Children and performance-based measures of inattention. *Dissertation Abstract International: Section B: The Sciences and Engineering, Vol. 61(9-B),* 4977.

DiMaio, S., Grizenko, N., & Joober, R. (2003). Dopamine genes and attention-deficit hyperactivity disorder: A review. *Journal of Psychiatry and Neuroscience, 28,* 27-38.

Douglas, V.I. (1972). Stop, look, and listen: The problem of sustained attention and impulse control in hyperactive and normal children. *Canadian Journal of Behavioural Science, 4,* 65-92.

Dulcan, M., Dunne, J.E., Ayres, W., Arnold, V., Benson, R.S., Bernet, W., et al. (1997). Practice parameters for the assessment and treatment of children, adolescents, and adults with attention-deficit/hyperactivity disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 36 (Suppl.),* 85S-121S.

Dykman, R.A., & Ackerman, P.T. (1991). ADD and specific reading disability: Separate but often overlapping disorders. *Journal of Learning Disorders, 2,* 96-103.

Faraone, S.V., Biederman, J., Lehman, B.K., Keenan, K., Norman, D., Seidman, L.J., et al. (1993). Evidence for the independent familial transmission of attention deficit hyperactivity disorder and learning disabilities: Results from a familial genetic study. *American Journal of Psychiatry, 150,* 891-895.

Faraone, S.V., Biederman, J., Weber, W., & Russell, R.L. (1998). Psychiatric, neuropsychological, and psychosocial features of DSM-IV subtypes of attention-deficit/hyperactivity disorder: Results from a clinically referred sample. *Journal of the American Academy of Child and Adolescent Psychiatry, 37,* 185-193.

Filipek, P.A., Semrud-Clikeman, M., Steingard, R.J., Renshaw, P.F., Kennedy, D.N., & Biederman, J. (1997). Volumetric MRI analysis comparing subjects having attention-deficit hyperactivity disorder with normal controls. *Neurology, 48,* 589-601.

Flanagan, D. P., & Kaufman, A. S. (2004). *Essentials of WISC-IV Assessment.* New Jersey: John Wiley & Sons, Inc.

Flanagan, D.P., McGrew, K.S., & Ortiz, S.O. (2000). *The Wechsler Intelligence Scales and Gf-Gc Theory.* Needham Heights, MA: Allyn & Bacon.

Frick, P.J., Kamphaus, R.W., Lahey, B.B., Loeber, R. Christ, M.A., Hart, E.L., et al. (1991). Academic underachievement and the disruptive behaviour disorders. *Journal of Consulting and Clinical Psychology, 59,* 289-294.

Gathercole, S.E., & Alloway, T.P. (2008). *Working Memory and learning: A practical guide for teachers*. London: Sage.

Gathercole, S.E., Pickering, S.J., Ambridge, B., & Wearing, H. (2004). The structure of working memory from 4 to 15 years of age. *Developmental Psychology, 40,* 177-190.

Gathercole, S.E., Pickering, S.J., Knight, C., & Stegmann, Z. (2003). Working memory skills and educational attainment: evidence from National Curriculum Assessments at 7 and 14 years of age. *Applied Cognitive Psychology, 18*, 1-16.

Geurts, H.M, Verte, S., Oosterlann, J., Roeyers, H., & Sergeant, J.A. (2004). ADHD subtypes: Do they differ in their executive functioning profile? *Archives of Clinical Neuropsychology, 20,* 457-477.

Goldman, L.S., Genel, M., Bexman, R.J., & Slanetz, P.J., (1998). Diagnosis and treatment of attention-deficit/hyperactivity disorder in children and adolescents. *Journal of the American Medical Association, 279,* 1100-1107.

Goodman, J.R., & Stevenson, J. (1989). A twin study of hyperactivity: II. The aetiological role of genes, family, relationships, and perinatal adversity. *Journal of Child Psychology and Psychiatry, 30,* 691-709.

Hendren, R. I., De Backer, I., & Pandina, G. I. (2000). Review of neuroimaging studies of child and adolescent psychiatric disorders from the past ten years. *Journal of the American Academy of Child & Adolescent Psychiatry, 39,* 815-828.

Himelstein, J., Schulz, K.P., Newcorn, J.H., & Halperin, J.M. (2000). The neurobiology of attention-deficit hyperactivity disorder. *Frontiers in Bioscience, 5,* 461-478.

Hindshaw, S.P. (1987). On the distinction between attentional deficits/hyperactivity and conduct problems/aggression in child psychopathology. *Psychological Bulletin, 101,* 443-463.

Jarratt, K.P., Ricco, C.A., Siekierski, B.M., & Becky, M. (2005). Assessment of attention deficit hyperactivity disorder (ADHD) using the BASC and BRIEF. *Applied Neuropsychology, 12,* 83-93.

Jensen, P., Shervette, R., Xenakis, S., & Richters, J. (1993). Anxiety and depressive disorders in attention deficit disorder with hyperactivity: New findings. *American Journal of Psychiatry, 150,* 1203-1209.

Jonsdottir, S., Bouma, A., Sergeant, J.A., & Scherder, E.J.A. (2004). The impact of specific language impairment on working memory in children with ADHD combined subtype. *Archives of Clinical Neuropsychology, 20,* 443-456.

Kamphaus, R.W., & Frick, P.J. (2002). *Clinical assessment of child and adolescent personality and behaviour* (2nd ed.). Boston: Allyn & Bacon.

Karatekin, C. (2004). A test of the integrity of the components of Baddeley's model of working memory in attention-deficit/hyperactivity disorder (ADHD). *Journal of Child Psychology and Psychiatry, 45,* 912-926.

Kempton, S., Vance, A., Maruff, P., Luk, E., Costin, J., & Pantelis, C. (1999). Executive function and attention deficit hyperactivity disorder: Stimulant medication and better executive function performance in children. *Psychological Medicine, 29,* 527-538.

Klingberg, T., Fernell, E., Olesen, P.J., Johnson, M., Gustafsson, P., Dahlstrom, K., et al. (2005). Computerized training of working memory in children with ADHD-a randomized, controlled trail. *Journal of the American Academy of Child and Adolescent Psychiatry, 44,* 177-186.

Lacene, K. (2003). *WAIS-III: Working memory and processing speed indexes in adults with attention deficit/hyperactivity disorder.* Unpublished doctoral thesis, University of Alberta.

Leffard, S.A., Miller, J.A., Bernstein, J., DeMann, J.J., Mangis, H.A., & McCoy, E.L. (2006). Substantive validity of working memory measures in major cognitive functioning test batteries of children. *Applied Neuropsychology, 13 (4),* 230-241.

Levy, F., Hay, D.A., McStephen, M., Wood, C., & Waldman, I. (1997). Attention-deficit hyperactivity disorder: A category or a continuum? Genetic analysis of a large-scale twin study. *Journal of American Academy of Child and Adolescent Psychiatry, 36,* 737-744.

Lockwood, K.A., Marcotte, A.C., & Stern, C. (2001). Differentiation of attention-deficit/hyperactivity disorder subtypes: Application of neuropsychological model of attention. *Journal of Clinical & Experimental Neuropsychology, 32,* 317-330.

Logie, R.H. (1995). *Visuo-spatial working memory.* Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Manning, S.C., & Miller, D.C. (2001). Identifying ADHD subtypes using the parent and teacher rating scales of the Behavior Assessment System for Children. *Journal of Attention Disorders, 5,* 41-51.

Mariani, M., & Barkley, R. A. (1997). Neuropsychological and academic functioning in preschool children with attention deficit-hyperactivity disorder. *Developmental Neuropsychology, 13,* 111-129.

Martinussen, R., Hayden, J., Hogg-Johnson, S., & Tannock, R. (2005). A meta-analysis of working memory impairments in children with attention deficit/hyperactivity disorder. *Journal of the American Academy of Children and Adolescent Psychiatry, 44,* 377-384.

Martinussen, R., & Tannock, R. (2006). Working memory impairments in children with attention-deficit hyperactivity disorder with and without comorbid language learning disorders. *Journal of Clinical and Experimental Neuropsychology, 28,* 1073-1094.

Marusiak, C.W., & Janzen, H.L. (2005). Assessing the working memory abilities of ADHD children using the Stanford-Binet Intelligence Scales, Fifth Edition. *Canadian Journal of School Psychology, 20,* 84-97.

Mayes, S.D., & Calhoun, S.L. (2004). Similarities and differences in Wechsler Intelligence Scale for Children-Third Edition (WISC-III) profiles: Support for subtest analysis in clinical referrals. *The Clinical Neuropsychologist, 18,* 559-572.

Mayes, S.D., & Calhoun, S.L. (2006). WISC-IV and WISC-III profiles in children with ADHD. *Journal of Attention Disorders, 9,* 489-493.

Mayer, S.D., Calhoun, S.L., & Crowell, E.W. (2000). Learning disabilities and ADHD: Overlapping spectrum disorder. *Journal of Learning Disabilities, 33,* 417-424.

McInnes, A., Humphries, T., Hogg-Johnson, S., & Tannock, R. (2003). Listening comprehension and working memory are impaired in attention-deficit hyperactivity disorder irrespective of language impairment. *Journal of Abnormal Child Psychology, 31,* 427-443.

McGrew, K.S. (2005). The Cattel-Horn-Carroll theory of cognitive abilities. In D.P. Flanagan & P.L. Harrison (Eds.), *Contemporary intellectual assessment: theories, tests, and issues (2nd ed.),* (p.136-181). New York: The Guilford Press.

Murphy, K.R., & Myors, B. (2004). *Statistical power analysis. A simple and general model of traditional and modern hypothesis tests (2nd ed.).* New Jersey: Lawrence Erlbaum Associates.

Naglieri, J.A. (1993). Pairwise and ipsative comparisons of WISC-III IQ and Index scores. *Psychological Assessment, 5,* 113-116.

Naglieri, J.A., & Goldstein, S. (2006). The role of intellectual processes in the DSM-V Diagnosis of ADHD. *Journal of Attention Disorders, 10,* 3-8.

Nigg, J.T., Hinshaw, S.P., Carte, E.T., & Treuting, J.J. (1998). Neuropsychological correlates of childhood attention-deficit/hyperactivity disorder: Explainable by comorbid disruptive behavior or reading problems? *Journal of Abnormal Psychology, 107,* 468-480.

Norman, D.A., & Shallice, T. (1980). *Attention to action: Willed and automatic control of behaviour.* University of California at San Diego, CHIP Report 99.

Oosterlaan, J., Scheres, A., & Sergeant, J.A. (2005). Which executive functioning deficits are associated with AD/HD, ODD/CD and comorbid AD/HD + ODD/CD? *Journal of Abnormal Child Psychology, 33,* 69-85.

Ostrander, R., Weinfurt, K.P., Yarnold, P.R., & August, G.J. (1998). Diagnosing attention deficit disorders with the Behavior Assessment System for Children and the Child Behavior Checklist: Test and construct validity analysis using optimal discriminant classification trees. *Journal of Consulting & Clinical Psychology, 66,* 660-672.

Pennington B.F, & Ozonoff S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychological Psychiatry, 37,* 51-87.

Perry, W., Heaton, R.K., Potterat, R., Roebuck, T., Minassian, A., & Braff, D.L. (2001). Working memory in schizophrenia: Transient "online" storage versus executive functioning. *Schizophrenia Bulletin, 27,* 157-176.

Petchers, P. (2007). *Analysis of profiles in a sample of students with attention deficit hyperactivity disorder using the Stanford-Binet Intelligence Scales, Fifth Edition.* Unpublished Doctoral Thesis, Fairleigh Dickinson University.

Phillips, J.L, Shiffrin, R.M., & Atkinson, R.C. (1967). Effects of list length on short-term memory. *Journal of Verbal Learning & Verbal Behavior, 6(3),* 303-311.

Pliszka, S.R. (2005). The neuropsychopharmacology of attention-deficit/hyperactivity disorder. *Biological Psychiatry, 57,* 1385-1390.

Pomplun, M., & Custer, M. (2005). The construct validity of the SB-5 measures of working memory, *Assessment, 12,* 338-346.

Portney, L.G, & Watkins, M.P. (2000). *Foundations of clinical research (2nd ed.).* Toronto: Prentice-Hall.

Rapport, M., Chung, K., Shore, G., & Isaacs, P. (2000). Upgrading the science and technology of assessment and diagnosis: Laboratory and clinic-based assessment of children with ADHD. *Journal of Clinical Child Psychology, 29,* 555-568.

Rapport, M., Chung, K., Shore, G., & Isaacs, P. (2001). A conceptual model of child psychopathology: Implications for understanding attention deficit hyperactivity disorder and treatment efficacy. *Journal of Clinical Child Psychology, 30,* 48-58.

Repovs, G., & Baddeley, A.D. (2006). The multi-component model of working memory: Explorations in experimental cognitive psychology. *Neuroscience, 139(1),* 5-21.

Reschly, D.J. (1997). Diagnostic and treatment utility of intelligence tests. In D.P. Flannagan, J.L. Genshaft, & P.L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (pp. 437-456). New York: Guilford.

Reynolds, C.R., & Kamphaus, R.W. (1992). *Behavior Assessment System for Children.* Circle Pines, MN.: American Guidance Service.

Reynolds, C.R., & Kamphaus, R.W. (2004). *Behavior Assessment System for Children, Second Edition.* Bloomington: Pearson Assessments.

Riccio, C.A., Homack, S., Jarratt, K.P., & Wolfe, M.E. (2006). Differences in academic and executive function domains among children with ADHD Predomantly Inattentive and Combined types. *Archives of Clinical Neuropsychology, 21,* 657-667.

Roid, G.H. (2003a). *Development of enhanced composite scores for clinical interpretation. Technical supplement for the Stanford-Binet Intelligence Scales-Fifth Edition.* Itasca, IL: Riverside Publishing.

Roid, G.H. (2003b). *Stanford-Binet Intelligence Scale-Fifth Edition.* Itasca IL: Riverside Publishing.

Roid, G.H. (2003c). *Stanford-Binet Intelligence Scale-Fifth Edition: Examiner's Manual.* Itasca IL: Riverside Publishing.

Roid, G.H. (2003d). *Stanford-Binet Intelligence Scale-Fifth Edition: Technical Manual.* Itasca IL: Riverside Publishing.

Roid, G.H. (2003e). *Stanford-Binet Intelligence Scales, Fifth Edition, Interpretive Manual.* Itasca, IL.: The Riverside Publishing Company.

Roid, G.H. (2005). *Interpretation of SB5/Early SB5 index scores: contrasting each factor Index score with the mean of an individual's profile of Factor Index scores.* Itasca, IL. The Riverside Publishing Company.

Roid, G.H., & Barram, R. A. (2004). *Essentials of Stanford-Binet Intelligence Scales Assessment.* Hoboken, NJ: John Wiley & Sons, Inc.

Roid, G.H., & Pomplun, M. (2005). Interpreting the Stanford-Binet Intelligence Scales, Fifth Edition. In D.P. Flanagan & P.L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues (2nd ed.)* (pp. 325-343). New York: The Guilford Press.

Rudner, M., & Ronnberg, J. (2008). The role of the episodic buffer in working memory for language processing. *Cognitive Process, 9,* 19-28.

Saklofske, D. H; Schwean, V. L; Yackulic, R. A; & Quinn, D. (1994). WISC-III and SB:FE performance of children with attention deficit hyperactivity disorder. *Canadian Journal of School Psychology, 10(2),* 167-171.

Santosh, P.J., Taylor, E., Swanson, J., Wigal, T., Chuang, S., Davies, M, et al. (2005). Reanalysis of the multimodal treatment study of attention-deficit/hyperactivity disorder (ADHD) based on ICD-10 criteria for hyperkinetic disorder (HD). *Clinical Neuroscience Research, 5,* 5-6.

Sattler, J. M. (2001). *Assessment of children: Cognitive applications (4th ed.).* La Mesa CA: Jerome M. Sattler Publisher, Inc.

Sandoval, J. (1998). Review of the Behavior Assessment System for Children. In J.C. Impara & B.S. Plake (Eds.), *Thirteenth Mental Measurements Yearbook* (pp. 128-131). Lincoln. NE: Buros Institute.

Schatz, D.B., & Rostain, A.L. (2006). ADHD with comorbid anxiety: A review of the literature. *Journal of Attention Disorders, 10,* 141-149.

Seidman, L.J, Valera, E.M., & Markris, N. (2005). Structural brain imaging of attention-deficit hyperactivity disorder. *Biological Psychiatry, 57,* 1263-1272.

Semrud-Clikeman, M., Biederman, J., Sprich-Buckminister, S., Lehman, B.K., Faraone, S.V., & Norman, D. (1992). Cormorbidity between ADDH and learning disabilities: A review and report in a clinically referred sample. *Journal of the American Academy of Child and Adolescent psychiatry, 31,* 439-448.

Sergeant, J.A., Geurts, H. Huijbregts, S., Scheres, A., & Oosterlaan, J. (2003). The top and the bottom of ADHD: A neurological perspective. *Neuroscience and Biobehavioral Reviews, 27,* 583-592.

Silver, L.B. (1981). The relationship between learning disabilities, hyperactivity, distractibility, and behavioural problems. *Journal of American Academy of Child Psychiatry, 20,* 385-397.

Shaywitz, B.A., Fletcher, J.R., & Shaywitz, S.E. (1995). Defining and classifying learning disabilities and attention-deficit/hyperactivity disorder. *Journal of Child Neurology, 10,* S50-S57.

Sheridan, M.A., Hinshaw, S., & D'Esposito, M. (2007). Efficiency of the prefrontal cortex during working memory in attention-deficit/hyperactiviy disorder. *Journal of American Academy of Child and Adolescent Psychiatry, 46(10),* 1357-1366.

Solanto, M.V., Arnsten, A.F.T., & Castellanos, F.X. (2001). *Stimulant drugs and ADHD: Basic and clinical neuroscience.* New York: Oxford University Press.

Sonuga-Barke, E.J. (2004). Causal models of Attention-deficit/Hyperactivity Disorder: From common simple deficits to multiple developmental pathways. *Biological Psychiatry, 57, 1231-1238*

Sonuga-Barke, E.J., Williams, E., Hall, M., & Saxton, T. (1992). Hyperactivity and delay aversion - III. The effect on cognitive style of imposing delay after errors. *Journal of Child Psychological Psychiatry, 33,* 189-194.

Stevens, J., Quittner, A.L., Zuckerman, J.B., & Moore, S. (2002). Behavioral inhibition, self-regulation of motivation, and working memory in children with attention deficit hyperactivity disorder. *Developmental Neuropsychology, 21,* 117-139.

Swanson, J., Arnold, L.E., Kraemer, H., Hechtman, L., Molina, B., Hinshaw, S., et al. (2008a). Evidence, interpretation, and qualification from multiple reports of long-term outcomes in the multimodal treatment study of children with ADHD (MTA), Part I. *Journal of Attention Disorders, 12 (1),* 4-14.

Swanson, J., Arnold, L.E., Kraemer, H., Hechtman, L., Molina, B., Hinshaw, S., et al. (2008b). Evidence, interpretation, and qualification from multiple reports of long -term outcomes in the multimodal treatment study of children with ADHD: Part II: Supporting details. *Journal of Attention Disorders 12(15),* 15-43.

Szatmari, P. (1992). The epidemiology of attention-deficit hyperactivity disorders. In G. Weiss (Ed.), *Child and adolescent psychiatry clinics of North America: Attention deficit hyperactivity disorder* (pp. 361-372). Philadelphia: Saunders.

Thorndike, R.L., Hagen, E.P., & Sattler, J.M. (1986). *The Stanford-Binet Intelligence Scale: Fourth Edition guide for administering and scoring.* Itasca: Riverside Publishing.

Volk, H.E., Neuman, R.J., & Todd, R.D. (2005). A systematic evaluation of ADHD and comorbid psychopathology in a population-based twin sample. *Journal of American Academy of Child and Adolescent Psychiatry, 44(8),* 768-775.

Wechsler, D. (1992). *Wechsler Intelligence Scale of Children-Third Edition.* San Antonio, TX: The Psychological Corporation.

Wechsler, D. (2003a). *Wechsler Intelligence Scale of Children-Fourth Edition: Administration and Scoring Manual.* San Antonio, TX: The Psychological Corporation.

Wechsler, D. (2003b). *Wechsler Intelligence Scale of Children-Fourth Edition: Technical and Interpretive Manual.* San Antonio, TX: The Psychological Corporation.

Weiss, M., Worling, D., & Wasdell, M. (2003). A chart review study of the Inattentive and Combined types of ADHD. *Journal of Attention Disorders, 7,* 1-9.

Willcutt, E.G., Doyle, A.E., Nigg, J.T., Faraone, S.V., & Pennington, B.F. (2005). Validity of the executive function theory of attention deficit/hyperactivity disorder: A meta-analytic review. *Biological Psychiatry, 57,* 1336-1346.

Willcutt, E.G., & Pennington, B.F. (2000). Comorbidity of reading disability and attention-deficit/hyperactivity disorder: Differences by gender and subtype. *Journal of Learning Disabilities, 3,* 179-191.

Willcutt, E.G., Pennington, B.F., Olson, R.K., Chhabildas N., & Hulslander, J. (2005). Neuropsychological analysis of comorbidity between reading disability and attention deficit hyperactivity disorder: In search of a common deficit. *Developmental Neuropsychology, 27,* 35-78.

Wootten, S.A. (1999). Attention-deficit/hyperactivity disorder. *Dissertation Abstracts International Section B: The Sciences and Engineering, 60 (1-B),* 0380.

Yeo, R.A., Hill, D.E., Campbell, R.A.,Vigil, J., Petropoulos, H., Hart, B., et al. (2003). Proton magnetic resonance spectroscopy investigation of the right frontal lobe in children with attention-deficit/hyperactivity disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 42*, 303-310.

Zametkin, A. J., Liebenauer, L.L., Fitzgerald, G.A., King, A.C., Minkunas, D.V., Herscovitch, P., et al. (1993). Brain metabolism in teenagers with attention-deficit hyperactivity disorder. *Archives of General Psychiatry, 50*, 333-340.

Zhu, J., & Weiss, L. (2005). The Wechsler Scales. In D.P. Flanagan & P.L Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues (2nd ed.),* (pp. 297-324). New York: The Guilford Press.

APPENDIX

Table 1a

MANOVA table for factor scores, ADHD-collapsed vs clinic control

Source	Variable	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	FR	557.877	2	278.939	1.652	0.195
	KN	435.976	2	217.988	1.243	0.291
	QR	905.596	2	452.798	3.116	0.047
	VS	540.424	2	270.212	1.975	0.142
	WM	2912.916	2	1456.458	7.026	0.001
Intercept	FR	1833513.069	1	1833513.069	10858.228	0.000
	KN	1733989.659	1	1733989.659	9889.950	0.000
	QR	1738870.576	1	1738870.576	11968.095	0.000
	VS	1838027.467	1	1838027.467	13434.743	0.000
	WM	1745460.600	1	1745460.600	8420.540	0.000
Group	FR	557.877	2	278.939	1.652	0.195
	KN	435.976	2	217.988	1.243	0.291
	QR	905.596	2	452.798	3.116	0.047
	VS	540.424	2	270.212	1.975	0.142
	WM	2912.916	2	1456.458	7.026	0.001
Error	FR	29888.101	177	168.859		
	KN	31033.135	177	175.328		
	QR	25716.715	177	145.292		
	VS	24215.637	177	136.812		

	WM	36689.634	177	207.286		
Total	FR	1867030.000	180			
	KN	1768038.000	180			
	QR	1768696.000	180			
	VS	1865585.000	180			
	WM	1790147.000	180			
Corrected Total	FR	30445.978	179			
	KN	31469.111s	179			
	QR	26622.311	179			
	VS	24756.061	179			
	WM	39602.550	179			

Table 1b

MANOVA table for factor scores, ADHD-combined vs clinic control

Source	Variable	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	FR	82.742	2	41.371	0.299	0.742
	KN	547.530	2	273.765	1.361	0.261
	QR	373.975	2	186.988	1.171	0.314
	VS	502.115	2	251.058	1.697	0.188
	WM	1513.690	2	756.845	3.423	0.036
Intercept	FR	857075.966	1	857075.966	6190.935	0.000
	KN	788292.013	1	788292.013	3920.339	0.000
	QR	804613.674	1	804613.674	5037.994	0.000

	VS	823777.255	1	823777.255	5566.704	0.000
	WM	792106.184	1	792106.184	3582.921	0.000
Group	FR	82.742	2	41.371	0.299	0.742
	KN	547.530	2	273.765	1.361	0.261
	QR	373.975	2	186.988	1.171	0.314
	VS	502.115	2	251.058	1.697	0.188
	WM	1513.690	2	756.845	3.423	0.036
Error	FR	14536.249	105	138.440		
	KN	21113.137	105	201.077		
	QR	16769.460	105	159.709		
	VS	15538.209	105	147.983		
	WM	23213.226	105	221.078		
Total	FR	1149089.000	108			
	KN	1075422.000	108			
	QR	1094545.000	108			
	VS	1121185.000	108			
	WM	1108931.000	108			
Corrected Total	FR	14618.991	107			
	KN	21660.667	107			
	QR	17173.435	107			
	VS	16040.324	107			
	WM	24726.917	107			

Table 1c

MANOVA table for factor scores, ADHD-inattentive vs clinic control

Source	Variable	Sum of Squares	df	Mean Square	F	Sig.
Corrected	FR	427.378	2	213.689	1.184	0.310
Model	KN	112.951	2	56.475	0.310	0.734
	QR	887.603	2	443.801	2.916	0.058
	VS	187.771	2	93.886	0.646	0.526
	WM	1939.266	2	969.633	4.630	0.012
Intercept	FR	1068636.946	1	1068636.946	5920.550	0.000
	KN	1021660.901	1	1021660.901	5604.902	0.000
	QR	1015933.127	1	1015933.127	6674.587	0.000
	VS	1101170.278	1	1101170.278	7578.661	0.000
	WM	1022610.200	1	1022610.200	4882.489	0.000
Group	FR	427.378	2	213.689	1.184	0.310
	KN	112.951	2	56.475	0.310	0.734
	QR	887.603	2	443.801	2.916	0.058
	VS	187.771	2	93.886	0.646	0.526
	WM	1939.266	2	969.633	4.630	0.012
Error	FR	21659.548	120	180.496		
	KN	21873.586	120	182.280		
	QR	18265.097	120	152.209		
	VS	17435.855	120	145.299		
	WM	25133.336	120	207.444		

Total	FR	1276204.000	123			
	KN	1212115.000	123			
	QR	1220126.000	123			
	VS	1291610.000	123			
	WM	1233982.000	123			
Corrected Total	FR	22086.927	122			
	KN	21986.537	122			
	QR	19152.699	122			
	VS	17623.626	122			
	WM	27072.602	122			

Table 1d

MANOVA table for factor scores, ADHD-hyperactive vs clinic control

Source	Variable	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	FR	979.078	2	489.539	2.770	0.070
	KN	72.779	2	36.389	0.162	0.851
	QR	261.246	2	130.623	0.727	0.490
	VS	143.730	2	71.865	0.465	0.630
	WM	439.808	2	219.904	0.861	0.427
Intercept	FR	209294.886	1	209294.886	1184.197	0.000
	KN	209049.362	1	209049.362	931.431	0.000
	QR	210987.799	1	210987.799	1163.212	0.000
	VS	219688.042	1	219688.042	1420.647	0.000

	WM	221242.721	1	221242.721	866.602	0.000
Group	FR	979.078	2	489.539	2.770	0.070
	KN	72.779	2	36.389	0.162	0.851
	QR	261.246	2	130.623	0.727	0.490
	VS	143.730	2	71.865	0.465	0.630
	WM	439.808	2	219.904	0.861	0.427
Error	FR	12371.798	70	176.740		
	KN	15710.728	70	224.439		
	QR	12696.864	70	181.384		
	VS	10824.763	70	154.639		
	WM	17870.932	70	255.299		
Total	FR	772231.000	73			
	KN	730069.000	73			
	QR	752791.000	73			
	VS	767200.000	73			
	WM	783116.000	73			
Corrected Total	FR	13350.877	72			
	KN	15783.507	72			
	QR	12958.110	72			
	VS	10968.493	72			
	WM	18310.740	72			

Table 1e

Means and SD for factor scores

	Clinic Control	Combined		Inattentive		Hyperactive		Collapsed	
		Sev	*Mod*	*Sev*	*Mod*	*Sev*	*Mod*	*Sev*	*Mod*
FR	102.8	103.0	100.5	99.3	99.0	103.0	86.8	101.5	98.6
	12.6	9.8	11.4	14.4	14.1	15.4	19.9	12.4	13.9
KN	99.3	100.7	93.8	98.0	97.1	98.1	95.0	99.3	96.0
	15.1	14.0	10.1	13.4	10.3	12.0	17.3	13.4	10.7
QR	101.5	98.0	97.2	95.7	96.4	96.3	96.0	96.9	96.6
	13.5	12.0	10.3	11.3	10.9	9.2	19.5	11.3	11.2
VS	102.2	101.9	96.2	103.4	100.0	101.6	96.0	102.5	98.6
	12.7	10.9	11.9	12.6	10.4	6.7	14.6	11.1	11.1
WM	102.6	99.8	92.0	98.4	93.5	105.4	92.8	99.9	93.0
	15.6	12.8	15.3	13.1	13.2	18.3	17.9	13.5	13.9

Table 2a

MANOVA table for subtest scores - ADHD-Collapsed

Source	Variable	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	NVWM	159.136	2	79.568	6.842	0.001
	NVQR	12.462	2	6.231	0.844	0.432
	VWM	51.887	2	25.944	3.457	0.034
	VQR	55.045	2	27.523	4.327	0.015
Intercept	NVWM	15231.192	1	15231.192	1309.637	0.000
	NVQR	18364.116	1	18364.116	2486.354	0.000
	VWM	18797.542	1	18797.542	2504.805	0.000
	VQR	15680.895	1	15680.895	2465.145	0.000
Group	NVWM	159.136	2	79.568	6.842	0.001
	NVQR	12.462	2	6.231	0.844	0.432
	VWM	51.887	2	25.944	3.457	0.034
	VQR	55.045	2	27.523	4.327	0.015
Error	NVWM	2058.525	177	11.630		
	NVQR	1307.315	177	7.386		
	VWM	1328.313	177	7.505		
	VQR	1125.905	177	6.361		
Total	NVWM	17545.000	180			
	NVQR	19722.000	180			
	VWM	20230.000	180			
	VQR	16917.000	180			

Corrected Total	NVWM	2217.661	179			
	NVQR	1319.778	179			
	VWM	1380.200	179			
	VQR	1180.950	179			

Table 2b

MANOVA table for subtest scores - ADHD-Combined

Source	Variable	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	NVWM	114.080	2	57.040	4.039	0.020
	NVQR	9.531	2	4.766	0.696	0.501
	VWM	32.106	2	16.053	2.282	0.107
	VQR	18.720	2	9.360	1.217	0.300
Intercept	NVWM	6609.412	1	6609.412	468.014	0.000
	NVQR	8400.234	1	8400.234	1226.507	0.000
	VWM	8763.917	1	8763.917	1245.780	0.000
	VQR	7508.187	1	7508.187	976.439	0.000
Group	NVWM	114.080	2	57.040	4.039	0.020
	NVQR	9.531	2	4.766	0.696	0.501
	VWM	32.106	2	16.053	2.282	0.107
	VQR	18.720	2	9.360	1.217	0.300
Error	NVWM	1482.837	105	14.122		
	NVQR	719.135	105	6.849		
	VWM	738.663	105	7.035		

	VQR	807.382	105	7.689		
Total	NVWM	11401.000	108			
	NVQR	12014.000	108			
	VWM	12573.000	108			
	VQR	11171.000	108			
Corrected Total	NVWM	1596.917	107			
	NVQR	728.667	107			
	VWM	770.769	107			
	VQR	826.102	107			

Table 2c

MANOVA table for subtest scores - ADHD-Inattentive

Source	Variable	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	NVWM	102.543	2	51.272	4.260	0.016
	NVQR	9.391	2	4.696	0.654	0.522
	VWM	23.051	2	11.525	1.690	0.189
	VQR	77.426	2	38.173	5.484	0.005
Intercept	NVWM	9161.516	1	9161.516	761.263	0.000
	NVQR	11067.117	1	11067.117	1541.031	0.000
	VWM	10652.933	1	10652.933	1562.517	0.000
	VQR	8703.898	1	8703.898	1232.977	0.000
Group	NVWM	102.543	2	102.543	4.260	0.016
	NVQR	9.391	2	9.391	0.654	0.522

	VWM	23.051	2	23.051	1.690	0.189
	VQR	77.426	2	77.426	5.484	0.005
Error	NVWM	1444.156	120	12.035		
	NVQR	861.796	120	7.182		
	VWM	818.136	120	6.818		
	VQR	847.111	120	7.059		
Total	NVWM	12695.000	123			
	NVQR	13799.000	123			
	VWM	13342.000	123			
	VQR	11714.000	123			
Corrected Total	NVWM	1546.699	122			
	NVQR	871.187	122			
	VWM	841.187	122			
	VQR	924.537	122			

Table 2d

MANOVA table for subtest scores - ADHD-Hyperactive

Source	Variable	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	NVWM	38.395	2	19.197	1.262	0.289
	NVQR	9.854	2	4.927	0.661	0.520
	VWM	3.515	2	1.758	0.249	0.780
	VQR	8.128	2	4.064	0.476	0.623
Intercept	NVWM	1963.114	1	1963.114	129.074	0.000

	NVQR	2097.517	1	2097.517	281.330	0.000
	VWM	2474.452	1	2474.452	350.132	0.000
	VQR	1986.811	1	1986.811	232.641	0.000
Group	NVWM	38.395	2	19.197	1.262	0.289
	NVQR	9.854	2	4.927	0.661	0.520
	VWM	3.515	2	1.758	0.249	0.780
	VQR	8.128	2	4.064	0.476	0.623
Error	NVWM	1064.646	70	15.219		
	NVQR	521.900	70	7.456		
	VWM	494.704	70	7.067		
	VQR	597.817	70	8.540		
Total	NVWM	8747.000	73			
	NVQR	8299.000	73			
	VWM	8515.000	73			
	VQR	7866.000	73			
Corrected Total	NVWM	1103.041	72			
	NVQR	531.753	72			
	VWM	498.219	72			
	VQR	605.945	72			

Table 2e

MANOVA table for subtest scores

	Clinic Control	Combined		Inattentive		Hyperactive		Collapsed	
		Sev	*Mod*	*Sev*	*Mod*	*Sev*	*Mod*	*Sev*	*Mod*
NVQR	10.5	9.8	10.1	10.3	9.8	9.6	9.3	10.0	9.9
	2.6	2.7	2.7	2.9	2.8	2.8	5.0	2.7	2.9
NVWM	10.4	8.8	7.8	9.2	8.3	10.7	7.3	9.2	8.1
	4.0	3.1	3.8	2.6	2.9	2.6	3.8	2.9	3.2
VQR	10.1	9.6	9.0	8.2	8.9	9.1	9.3	9.0	9.0
	3.1	2.4	2.0	2.3	2.0	1.1	2.2	2.3	2.0
VWM	10.4	11.1	9.4	10.2	9.4	11.1	10.3	10.8	9.5
	2.5	2.5	3.5	2.8	2.7	4.1	2.9	2.8	2.9

Table 3a

ANOVA table for QR Difference Scores: ADHD-collapsed

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	369.080	2	184.540	3.267	0.040
Within Groups	998.392	177	56.488		
Total	10367.472	179			

Table 3b

ANOVA table for WM Difference Scores: ADHD-collapsed

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	653.909	2	326.954	4.159	0.017
Within Groups	13913.918	177	78.610		
Total	14567.826	179			

Table 3c

ANOVA table for QR Difference Scores: ADHD-combined

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	192.316	2	96.158	1.548	0.217
Within Groups	6521.919	105	62.114		
Total	6714.235	107			

Table 3d

ANOVA table for WM Difference Scores: ADHD-combined

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	331.909	2	165.955	2.049	0.134
Within Groups	8504.608	105	80.996		
Total	8836.517	107			

Table 3e

ANOVA table for QR Difference Scores: ADHD-inattentive

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	162.005	2	81.003	1.475	0.233
Within Groups	6591.322	120	54.928		
Total	6753.327	122			

Table 3f

ANOVA table for WM Difference Scores: ADHD-inattentive

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	500.587	2	250.294	3.080	0.050
Within Groups	9752.848	120	81.274		
Total	10253.435	122			

Table 3g

ANOVA table for QR Difference Scores: ADHD-hyperactive

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	164.005	2	82.003	1.518	0.226
Within Groups	3782.559	70	54.037		
Total	3946.564	72			

Table 3h

ANOVA table for WM Difference Scores: ADHD-hyperactive

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	94.075	2	47.038	0.540	0.585
Within Groups	6102.818	70	87.183		
Total	6196.893	72			

Table 3i

Difference score means and SD for factors

Variable	*CC*	ADHD SUBTYPES Combined Sev	 Mod	 Inattentive Sev	 Mod	 Hyperactive Sev	 Mod	 Collapsed Sev	 Mod
DQR	0.2	2.6	-1.3	3.3	0.8	4.6	-2.7	3.1	-0.0
	7.6	9.1	6.5	6.5	7.7	6.2	4.1	7.8	7.2
DWM	-1.0	0.9	3.9	0.6	3.7	-4.5	0.6	0.1	3.5
	9.3	8.7	8.1	8.0	9.0	10.5	6.0	8.7	8.5

Table 4a

ANOVA table for NVQR Difference Scores: ADHD-collapsed

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11.443	2	5.721	1.668	0.192
Within Groups	607.226	177	3.431		
Total	618.669	179			

Table 4b

ANOVA table for NVWM Difference Scores: ADHD-collapsed

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	42.852	2	21.426	3.814	0.024
Within Groups	994.374	177	5.618		
Total	1037.226	179			

Table 4c

ANOVA table for VQR Difference Scores: ADHD-collapsed

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33.411	2	16.705	4.698	0.010
Within Groups	629.365	177	3.556		
Total	662.776	179			

Table 4d

ANOVA table for VWM Difference Scores: ADHD-collapsed

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17.492	2	8.746	2.396	0.094
Within Groups	646.041	177	3.650		
Total	663.532	179			

Table 4e

ANOVA table for NVQR Difference Scores: ADHD-combined

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11.778	2	5.889	1.774.	0.175
Within Groups	348.643	105	3.320		
Total	360.421	107			

Table 4f

ANOVA table for NVWM Difference Scores: ADHD- combined

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	42.295	2	21.147	3.211	0.044
Within Groups	691.531	105	6.586		
Total	733.826	107			

Table 4g

ANOVA table for VQR Difference Scores: ADHD- combined

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.936	2	4.468	1.188	0.309
Within Groups	394.831	105	3.760		
Total	403.767	107			

Table 4h

ANOVA table for VWM Difference Scores: ADHD- combined

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.477	2	4.739	1.350	0.264
Within Groups	368.424	105	3.509		
Total	377.901	107			

Table 4i

ANOVA table for NVQR Difference Scores: ADHD-inattentive

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.823	2	1.911	0.584	0.559
Within Groups	392.687	120	3.272		
Total	396.510	122			

Table 4j

ANOVA table for NVWM Difference Scores: ADHD- inattentive

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	30.978	2	15.489	2.731	0.069
Within Groups	680.624	120	5.672		
Total	711.603	122			

Table 4k

ANOVA table for VQR Difference Scores: ADHD- inattentive

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	42.972	2	21.486	5.749	0.004
Within Groups	448.491	120	3.737		
Total	491.463	122			

Table 4l

ANOVA table for VWM Difference Scores: ADHD- inattentive

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.602	2	2.801	0.754	0.473
Within Groups	445.614	120	3.713		
Total	451.216	122			

Table 4m

ANOVA table for NVQR Difference Scores: ADHD-hyperactive

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12.006	2	6.003	1.998	0.143
Within Groups	210.314	70	3.004		
Total	222.320	72			

Table 4n

ANOVA table for NVWM Difference Scores: ADHD-hyperactive

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.533	2	1.266	0.195	0.823
Within Groups	453.694	70	6.481		
Total	456.227	72			

Table 4o

ANOVA table for VQR Difference Scores: ADHD-hyperactive

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.616	2	2.808	0.768	0.468
Within Groups	255.817	70	3.655		
Total	261.433	72			

Table 4p

ANOVA table for VWM Difference Scores: ADHD-hyperactive

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.401	2	2.200	0.585	0.560
Within Groups	263.395	70	3.763		
Total	267.795	72			

Table 4q

Difference Score Means and SD for subtests.

Variable	*CC*	*ADHD SUBTYPES*							
		Combined		Inattentive		Hyperactive		Collapsed	
		Sev	Mod	Sev	Mod	Sev	Mod	Sev	Mod
DNVQR	-0.2	0.0	-1.0	-0.6	-0.5	0.6	-1.6	-0.2	-0.7
	1.7	2.0	1.8	1.9	1.9	1.9	1.6	2.0	1.9
DNVWM	-0.1	1.1	1.3	0.5	1.0	-0.6	0.4	0.7	1.1
	2.6	2.4	2.5	1.9	2.2	1.7	1.9	2.2	2.2
DVQR	0.2	0.9	0.5	1.8	0.8	1.1	0.8	1.2	0.7
	2.0	1.8	1.9	1.9	1.9	1.2	1.4	1.8	1.8
DVWM	-0.1	-0.7	0.1	-0.3	0.3	-0.9	-0.2	-0.6	0.2
	1.9	1.7	2.0	1.6	2.1	2.5	1.7	1.8	2.1

Table 5a

MANOVA power tables, uncorrected

	Combined	Inattentive	Hyperactive	Collapsed
Overall (factor level-Wilks 'Lambda)	.57	.76	.47	.90*
FR	.10	.26	.53	.35
KN	.29	.10	.07	.27
QR	.25	.56	.17	.59
VS	.35	.16	.12	.41
WM	.63	.77	.19	.93*
Overall (subtest level-Wilks 'Lambda)	.78	.84*	.65	.91*
NVQR	.17	.16	.16	.19
NVWM	.71	.74	.27	.92*
VQR	.26	.84*	.13	.75
VWM	.46	.35	.09	.64

*Power ranges of .80 or above is considered adequate

Table 5b.

MANOVA power tables, corrected for number of comorbid conditions

	Combined	Inattentive	Hyperactive	Collapsed
Overall (factor level-Wilks 'Lambda)	.67	.66	.40	.87*
FR	.43	.39	.74	.55
KN	.65	.37	.71	.51
QR	.33	.86*	.54	.75
VS	.53	.22	.32	.59
WM	.58	.71	.19	.89*
Overall (subtest level-Wilks 'Lambda)	.92*	.80*	.66	.91*
NVQR	.19	.61	.51	.39
NVWM	.69	.67	.24	.88*
VQR	.33	.91*	.31	.79
VWM	.80*	.32	.10	.67

*Power ranges of .80 or above is considered adequate

Table 6a. Intra individual analysis

ANOVA power tables, uncorrected

	Combined	Inattentive	Hyperactive	Collapsed
FR-difference	.26	.08	.37	.08
KN-difference	.19	.21	.12	.22
QR-difference	.32	.31	.31	.62
VS-difference	.07	.51	.07	.25
WM-difference	.41	.59	.14	.73
NVQR-difference	.36	.15	.40	.35
NVWM-difference	.60	.53	.08	.69
VQR-difference	.26	.86*	.18	.78
VWM-difference	.29	.18	.14	.48

*Power ranges: .80 or above: adequate

Table 6b

ANOVA power tables, corrected for number of comorbid conditions

	Combined	Inattentive	Hyperactive	Collapsed
FR-difference	.24	.08	.31	.08
KN-difference	.32	.23	.42	.21
QR-difference	.30	.51	.28	.56
VS-difference	.06	.49	.09	.21
WM-difference	.49	.67	.36	.78*
NVQR-difference	.31	.45	.40	.39
NVWM-difference	.79*	.54	.14	.76
VQR-difference	.32	.82*	.15	.72
VWM-difference	.27	.26	.33	.43

*Power ranges: .80 or above: adequate

Table 7

DATA SHEET

Collector

Date:

Case number		DOB	
Date of assessment		Gender	
Age at assessment		Grade	
Repeated grade	No = 1 yes =2 (record grade)	IPP	No=0 Yes=1
Ethnic background	Not known=0 White=1 Native=2 Other=3	Lives with	Both parent - 1 Parent/step parent=2 Single.parent=3 Other=4 (specify)

Variable	Description/Explanation
Referral source	School=1 Medical=2 Parent/guardian=3 other=4
Placement in sp classes	None=0; LD=1; Behavioural=2; life skills=3; other=4
Evidence of symptoms before age 7	No=0 Yes=1 not mentioned=3
Negative impact	None=0 (ie those cases with no evidence of symptoms before age 7); Home only=1; school only=2; both=3
Previous Hospitalization	No=0 Yes=1 Reason:
Head injury	No=0 Yes=1
Prev diagnosis of ADHD	None=0 Psychologist=2 Medical=3 Others=4 Note DSM
Prev cognitive testing	No=0 SB=1 WISC=2 KBIT=3 other = 4
Previous: FSIQ (all scores)	
Previous develop. diagnosis	None=0 RD=1 Math D=2 NVLD=3 MR=4 other=5

Current psychiatric diagnosis	None=0 conduct d/o=1 ODD=2 mood d/o=3; psychosis=4 anxiety=5 Tourette's=6 sleep d/o=7 ASD=8 FASD=9 other=10 (record)
Second psychiatric diagnosis	None=0 conduct D/O=1 ODD=2 mood d/o=3; psychosis=4 anxiety=5 Tourette's=6 sleep d/o=7 ASD=8 FASD=9 other=10 (record)
AXIS III	None=0 yes=1 Dx:
Familial Hx of Psychiatric	None=0 Parents=1, siblings=2, others=3
Familial Hx of ADHD	None=0 father=1 Mother=2 siblings=3, others=4
Familial Hx of Medical	None=0 Parents=1, siblings=2, others=3
Familial Hx of educational	None=0 Parents=1, siblings=2, others=3
Extra assistance (circle all that applies)	None=0 Resource room=1 tutor=2 ESL=3 OT=4 Others=5
Extra therapies/assessments	None=0 SLP=1 OT=2 others=3
Prev psychiatric evaluation	No=0 Yes=1 (record results/diagnosis/treatment/meds)
Congenital conditions	None=0 premature birth=1 genetic disorders=2 Post delivery complications=3 other=4
Adoption	No=0 yes=1
Involvement with social services/child welfare	None=0 Assistance=1 Placement outside of home (Foster care; TGO; PGO)=2
ADHD meds	None=0 yes=1 (Rx)
Psych meds	None=0 yes=1 (Rx)
Physical meds	No=0 yes=1 (Rx)
Abuse history	None=0; sexual=1 physical=2 neglect=3 multiple=4
Legal history	None=0 suspensions=1 expulsions=2 charges=3 youth detention=4 other=5
Sub use history	None=0 alc=1 illicit substances=2 both=3

BASC or BASC-2-PRS

(record norms used: Gender or General norms)

Mother=1   Father=2   guardian=3   step-parent=4

PRS-Externalizing Problems		PRS-Internalizing Problems:	
PRS-Adaptive Skills Scale		PRS-BSI	
PRS-Hyperactivity		PRS-Aggression	
PRS-Conduct Problems		PRS-Anxiety	
PRS-Depression		PRS-Somatization	
PRS-Atypicality		PRS-Withdrawal	
PRS-Attention Problems		PRS-Adaptability	
PRS-Social Skills		PRS-Leadership	
Activities of Daily Living		Functional Communication	

BASC or BASC-2-TRS

(record norms used: Gender or General norms)

TRS-Externalizing Problems		TRS-Internalizing Problems:	
TRS-School Problems		TRS-Adaptive Skills Scale	
TRS-BSI			
TRS-Hyperactivity		TRS-Aggression	
TRS-Conduct Problems		TRS-Anxiety	
TRS-Depression		TRS-Somatization	
TRS-Attention Problems		TRS-Learning Problems	
TRS-Atypicality		TRS-Withdrawal	
TRS-Adaptability		TRS-Social Skills	
TRS-Leadership		TRS-Study Skills	
Functional Communication			

BASC or BASC-2-SR

(record norms used: Gender or General norms)

Attitude to school		Attitude to teacher	
Sensation seeking		Atypicality	
Locus of Control		Somatization	
Social Stress		Anxiety	
Depression		Sense of Inadequacy	
Relations with Parents		Interpersonal Relations	
Self-Esteem		Self-Reliance	
Attention Problems		Hyperactivity	

School Problems		Internal Problems	
Attention/Hyperactivity			
Personal Adjustment		Emotional Symptom Index	

SIDAC-R

SIDAC-R(M. Depres.)	No=0, Yes=1
SIDAC-R (Dysthymic)	No=0, Yes=1
SIDAC-R (ADHD)	No=0, ADHD-C=1, ADHD-I=2, ADHD-H=3, ADHD-NOS=4
SIDAC-R (ODD)	No=0, Yes=1
SIDAC-R (CD)	No=0, Yes=1
SIDAC-R (Sep Anxiety)	No=0, Yes=1
SIDAC-R(Overanxious))	No=0, Yes=1
SIDAC-R (Psychot)	No=0, Yes=1

Stanford-Binet 5 scores

FSIQ		NVIQ	
VIQ		*FR*	
KN		*QR*	
VS		*WM*	
FR-NV		FR-V	
KN-NV		KN-V	
QR-NV		QR-V	
VS-NV		VS-V	
WM-NV		WM-V	

Other tests completed same time as SB (list them)	
WIAT or WIAT-II (standard scores)	(Composites) Read= Written= Math= etc
WRAT-3 (standard scores)	Read= Spell= Arith=
VMI (Beery)	Standard score
Reynolds Dep scale	TS=
WJ-III	Broad Read= Broad Math= Broad Written Language=
Connors ADHD Scale	
PPVT-III	
Other Tests	

CONNERS	mother	father	other
Hyperactivity			
Anxious-Shy			
Perfectionism			
Social Problems			
Psychosomatic			
Conners ADHD Index			
Conners Global Index			
Restless-Impulsive			
Conners Global Index-Emotional Liability			
Conners Global Index-Total			
DSM-IV Inattentiive			
DSM-IV Hyperactive-Impulsive			
DSM-IV Total			

Referral Question:

Conclusion of assessment:

Figure 4.1

Graph of WM difference score, study group and ADHD subtypes, including collapsed.

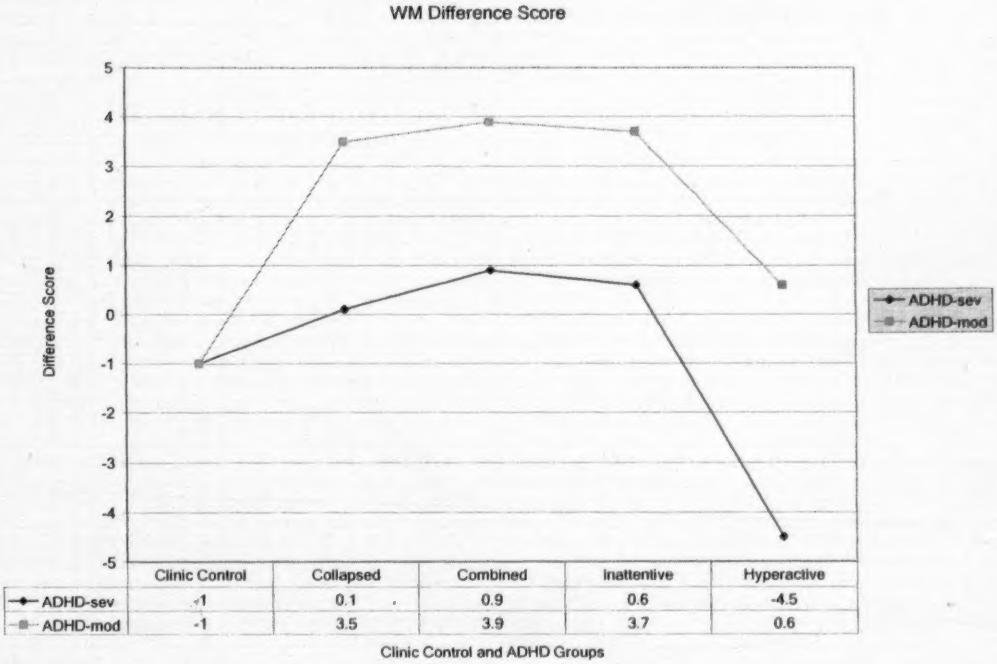
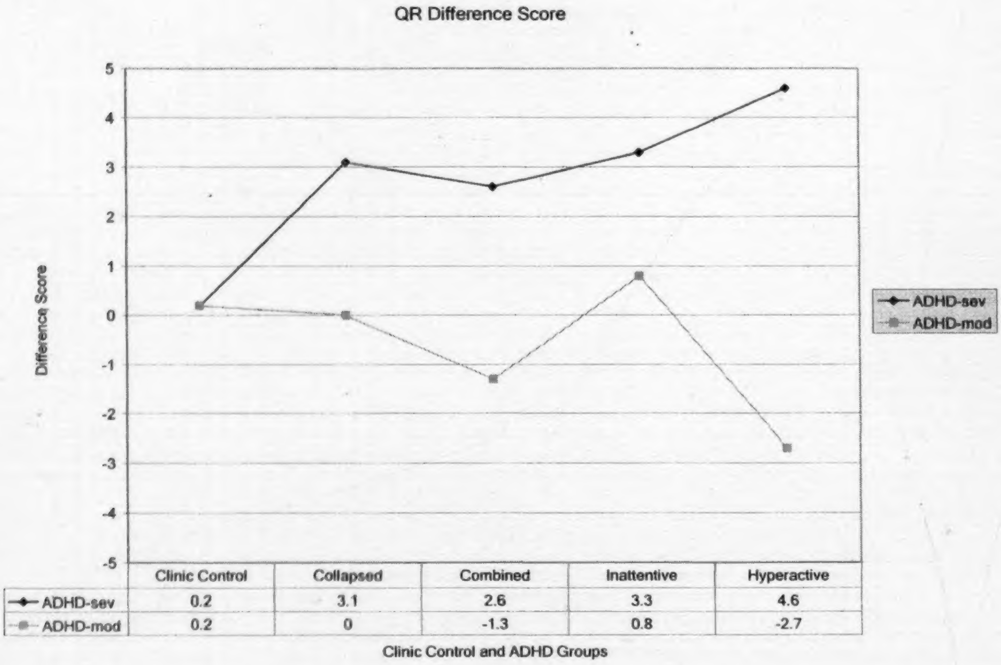


Figure 4.2

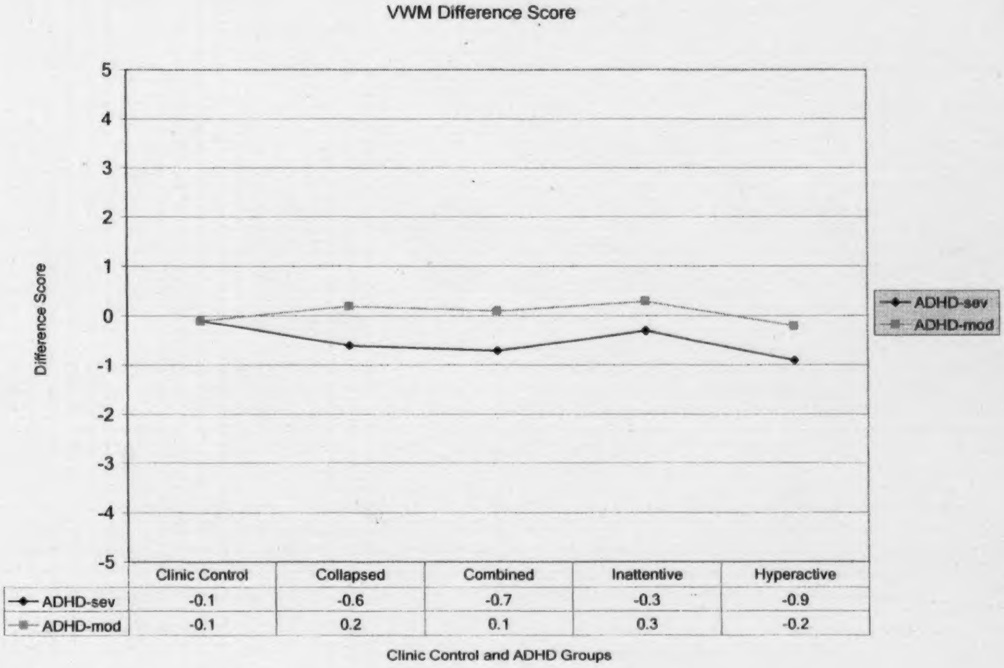
Graph of QR difference score, study group and ADHD subtypes, including collapsed.



	Clinic Control	Collapsed	Combined	Inattentive	Hyperactive
ADHD-sev	0.2	3.1	2.6	3.3	4.6
ADHD-mod	0.2	0	-1.3	0.8	-2.7

Figure 4.3

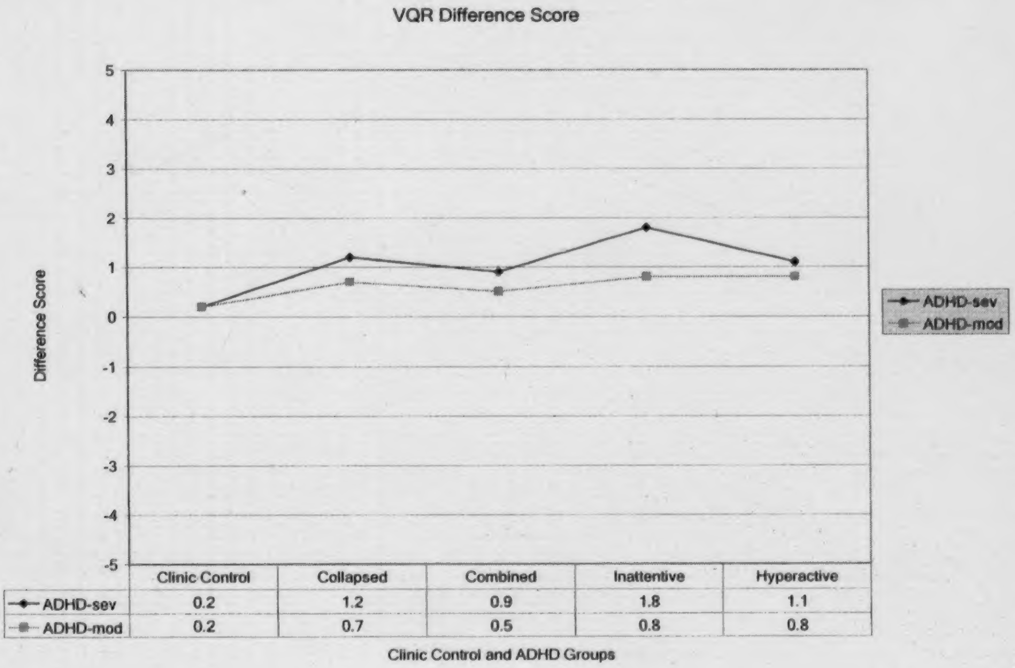
Graph of VWM difference score, study group and ADHD subtypes, including collapsed.



	Clinic Control	Collapsed	Combined	Inattentive	Hyperactive
ADHD-sev	-0.1	-0.6	-0.7	-0.3	-0.9
ADHD-mod	-0.1	0.2	0.1	0.3	-0.2

Figure 4.4

Graph of VQR difference score, study group and ADHD subtypes, including collapsed.



	Clinic Control	Collapsed	Combined	Inattentive	Hyperactive
ADHD-sev	0.2	1.2	0.9	1.8	1.1
ADHD-mod	0.2	0.7	0.5	0.8	0.8

Figure 4.5

Graph of NVWM difference score, study group and ADHD subtypes, including collapsed.

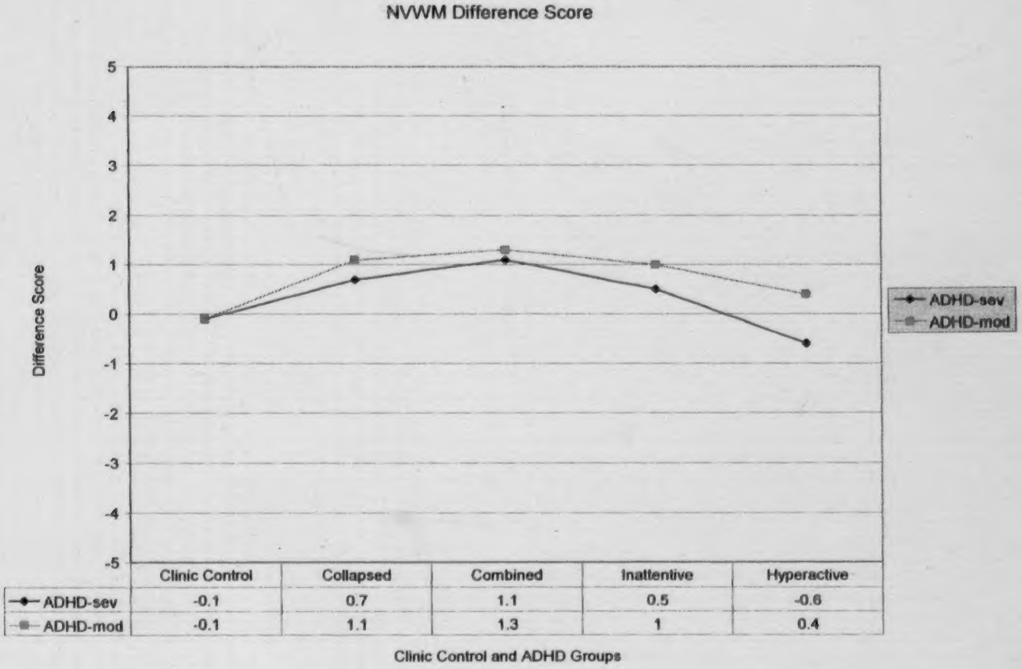
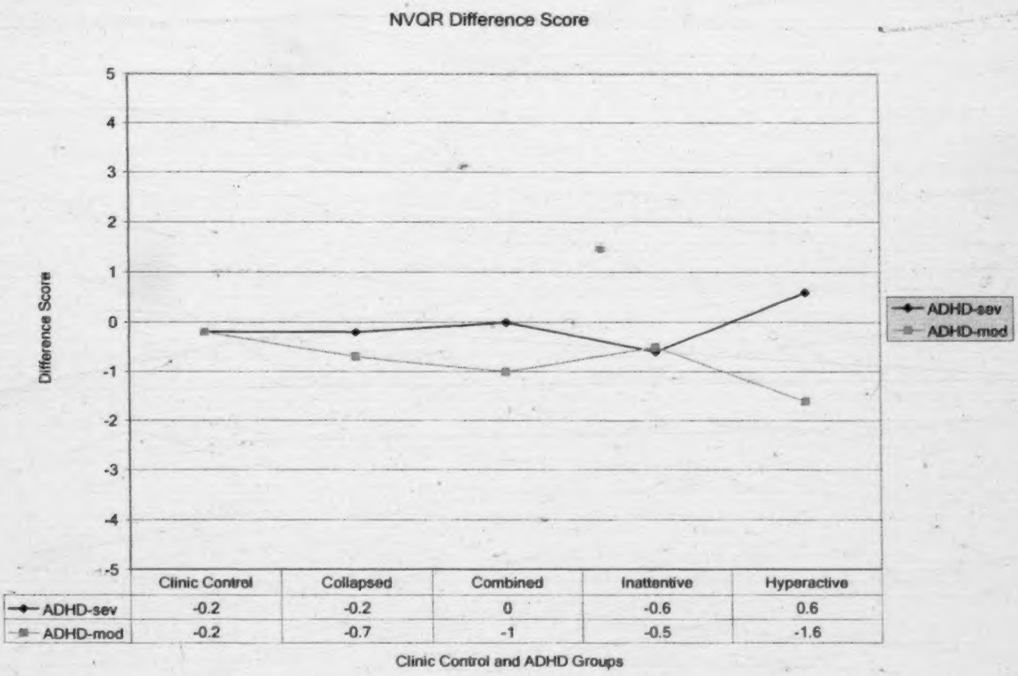


Figure 4.6

Graph of NVQR difference score, study group and ADHD subtypes, including collapsed.



	Clinic Control	Collapsed	Combined	Inattentive	Hyperactive
ADHD-sev	-0.2	-0.2	0	-0.6	0.6
ADHD-mod	-0.2	-0.7	-1	-0.5	-1.6